

facts furphies and furphies in benefit-cost analysis: transport

furphy 'fa John Farphy, manufacturer in Victoria of water and sanitation carts, which during World War I were centres of gossip] furred fod, *adj.* 1, having fur. 2, made with or of fur, as report 100



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PREFACE

Furphies about benefit-cost analysis (BCA) have a way of enduring.

Various economists — Herbert Mohring, Mitchell Harwitz and E.J. Mishan, to name a few — have made admirable attempts to dispel them. Much of their work is decades old, yet many of the same furphies continue to be accepted uncritically.

The problem is partly that many furphies are self-serving. Many exaggerate a project's benefits to society and so appeal to would-be beneficiaries. Other furphies can appeal to project opponents by exaggerating costs.

But the problem also lies partly with communication. Much of the theory behind BCA is complex, and the literature on the subject is mainly written for economists (or their students). Explanations for laymen are mostly too technical for the audience or, at the other extreme, too simplistic.

In renewing the fight for enlightenment, the BTE has endeavoured to make this report accessible to non-economists, but without sacrificing intellectual rigour. Parts of the report may not be a light read because the issues are indeed complex. Yet patient readers will be rewarded with insights into BCA, especially as applied to transport projects. The report is not, however, intended to be a comprehensive guide to BCA.

Dr David Luskin was the principal author. Dr Leo Dobes initiated the project and contributed chapter 13 on multi-criteria analysis.

Dr Leo Dobes Deputy Executive Director

Bureau of Transport Economics Canberra November 1999 iii

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ABBREVIATIONS

BCA	benefit-cost analysis
BTE	Bureau of Transport Economics
CBR-10	the interest rate on ten-year Australian Government ('Commonwealth') bonds
CEA	cost-effectiveness analysis
CTCS	change in transport consumer surplus
CV	compensating variation in income
EV	equivalent variation in income
GDP	gross domestic product
GE	general equilibrium
GST	goods and services tax
HSR	high-speed rail
10	input-output
MCA	multi-criteria analysis
MTPR	marginal time preference rate
NPV	net present value
PBS	planning balance sheet
PE	partial equilibrium
PDV	present discounted value
RIAM	Road Infrastructure Assessment Model (BTE)
SP	stated preference
STPR	social time preference rate
ТОС	total operating cost
VFT	very fast train

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ABSTRACT

Benefit-cost analysis (BCA) is a valuable and widely used tool. To reduce the odds of misuse, this report probes some important methodological issues, especially as they relate to transport projects. The discussion is relatively non-technical and draws on case studies.

The issues examined include claims that transport projects fail to measure certain benefits: employment creation, regional development, logistic adaptations and 'positive externalities'. Also examined are the choice of discount rate, the treatment of taxes, the valuation of travel time, multi-criteria analysis as an alternative to BCA, and the role of national economic models.

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...AT A GLANCE

- Improvements to transport can induce adaptations beyond transport, such as expansions of output by regional industries. BCAs tend to measure the benefits from these adaptations obliquely, inferring their magnitudes from transport outcomes. To add further, more direct measures of these benefits will usually result in double counting.
- Improvements to transport often provide a smaller stimulus to regional economies than is claimed. Many projects reduce regional transport costs by only a small proportion, and transport costs are only one component of regional production costs (and generally not a large one). Natural resource constraints, such as availability of water, may further limit any potential regional development effects.
- Many proponents of public investment in transport infrastructure emphasise job creation. However, the use of workers on an infrastructure project may reduce the availability of workers elsewhere in the economy. In addition, the financing of a public project requires increases in taxes, reductions in other public expenditure or borrowing, any of which could reduce employment. Estimates of the overall employment effect of a transport project will generally be speculative because of difficulties in modelling labour markets.
- BCAs have tended to omit or measure crudely some of the benefits from logistic adaptations to transport improvements. The adaptations can include warehouse consolidation and reductions in inventories. Further research is required into the value of travel time.
- BCAs usually fail to measure the social costs of financing public projects. Higher income taxes, for example, can create social costs by reducing incentives to work and to save. It is difficult to measure these costs with confidence, and rules of thumb may be too crude. The recent enactment of a GST may warrant changes to the treatment of commodity taxes in Australian BCAs.
- The widespread practice of obtaining a discount rate by adding a risk premium to the Commonwealth bond rate is hard to defend. More sophisticated treatments of risk, while difficult, are worth pursuing.
- It is not clear that national economic models hold any advantage over the standard tools of BCA. They are also more costly. Popular macroeconomic indicators, such as real GDP and the current account deficit, are of questionable relevance. A transport project could benefit society greatly and yet increase the current account deficit.
- Transport projects can generate positive environmental externalities, but they are often difficult to measure. Claims that BCAs omit benefits from other 'positive externalities' should be treated with caution.
- Multi-criteria analysis can be useful in highlighting aspects of a project that are of particular community or other interest. However, the use of arbitrary weights and lack of a standard methodology increases the scope for misuse, deliberate or not.

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Benefit-cost analysis (BCA) means different things to different people. As defined in this report, it is basically what the name suggests: an analysis of the benefits and costs to society of some action. In addition, a BCA attempts to value benefits and costs in monetary terms as far as possible and to produce a summary measure of net benefit. Some people prefer 'cost-benefit analysis' to 'benefit-cost analysis', but the meaning is the same.¹

To stress the societal perspective, some people refer to 'social' BCA, although 'BCA' is adequate. The contrast is often with financial analysis from the perspective of a business. A financial analysis of a private tollway, for example, would include any costs to the business of constructing sound barriers. But it would ignore the cost to society of the remaining noise, unless the business were somehow made to pay for it. A BCA, on the other hand, would want to consider the costs of both the barrier and any remaining noise.

What actions are analysed?

The actions analysed are usually in the government sphere. In transport, most BCAs concern infrastructure projects, such as highway construction. Although the projects are mainly public, ownership of the infrastructure may be private or mixed. Private projects can occasion BCAs when they depend on government approval or contribution. Some transport BCAs concern regulatory

^{1 &#}x27;Benefit-cost analysis' is the less common term. When pitted against 'cost-benefit analysis' in a web search, it yielded only 12 per cent of the near 25,000 hits. (The search engine was Hotbot.) However, its occurrence rose to 36 per cent after restricting the search to government addresses (with the suffix 'gov'). Government organisations that use 'benefit-cost analysis' include Austroads and the US Office of Management and Budget. The BTE has used both terms, reflecting personal preferences of the staff.

actions, such as changes to limits on truck weight. The 'project', in this report, is the action being analysed, and so includes regulatory changes; however, the focus of the report is on infrastructure investment.

In Australia, and probably in most countries, roads dominate discussions of transport BCA. For one thing, they command the lion's share of Australian public investment in transport. As a rough indication, road transport drew about \$3.5 billion in public capital outlays in 1996–97, significantly more than rail and multi-modal (\$1.9 billion), and vastly more than water and air transport (\$0.4 billion; ABS 1998b, p. 23). In addition, outside the road sector, public provision of transport infrastructure is quasi-commercial, and the authorities generally perform financial analyses, rather than BCAs, for internal investment appraisals (Abelson 1994, p. iv). For this reason too, transport BCAs are usually about road projects.

How is society defined?

Some BCAs define society around national boundaries. For example, the US Government has advised its agencies:

Analyses should focus on benefits and costs accruing to citizens of the United States in determining net present value. Where programs or projects have effects outside the United States, these effects should be separately reported (OMB 1992, p. 6).

But to incorporate national distinctions in a BCA is far easier said than done. Thus many BCAs end up estimating the net benefits for global society, if only implicitly. More difficult still, although sometimes attempted, is to estimate net benefits accruing to a subnational society, such as that of a region (see discussion in chapter 10).

How are benefits and costs valued?

Standard practice in BCA is to place monetary values on benefits and costs as far as possible. The practice permits the summation of sundry benefits and costs into an overall measure of net benefit.

For the most part, BCAs attempt to value benefits and costs as would the people to whom they accrue. In so doing, they respect the principle of consumer sovereignty: that individuals are usually their own best judges of what is good for them. If a project will provide, say, a subsidised bus service for the elderly, the question is how much the elderly value these services themselves. The question is not whether their use of buses gives other people sentimental satisfaction.

To understand the basis for valuation, take the case of time savings for non-business travel. For the travellers, such savings are equivalent to some increase in their income. Say that people are indifferent between receiving a windfall of \$10 and saving an hour off their trip to the beach. A BCA of a highway to the beach would then value an hour saved at \$10, that is, the 'equivalent variation' in income (EV).²

The net benefit from a project, based on such individualistic valuations, is known as the gain in 'economic efficiency' (or, equivalently, 'economic welfare'). A standard criterion for evaluating projects is whether the gain in economic efficiency is positive.

What about discount rates?

Also standard in BCA is the practice of discounting: assigning a smaller weight to benefits and costs that lie further in the future than to those that are more imminent. For example, at the discount rate of 7 per cent used for many road projects in Australia, a \$1.07 in benefit a year from now counts for only a \$1.00 benefit today. Like most discount rates, the 7 per cent is a real rate, over and above any adjustment for inflation. Discounting is warranted because real interest rates are normally positive: benefits that come sooner rather than later have an interest-earning advantage.

The choice of discount rate has sparked heated debate for decades, and can markedly affect BCA results. Chapter 6 recommends some general principles.

Are moral concerns ignored?

Economists, as social scientists, tend to shrink from moral judgements. Science focuses on objective realities, whereas morality is largely subjective. But one moral judgement — the Pareto principle — is central to economics, minimalist though it may seem. The Pareto principle deems to be socially desirable that which makes *everyone* better off.

At first blush, the Pareto principle might appear inapplicable to BCA. Almost any project under scrutiny produces winners and losers, rather than making everyone better off. A new airport, for example,

² An alternative measure of welfare gain (or loss) is the 'compensating variation' in income (CV). In the above beach example, the CV is the amount of income reduction that would exactly offset the welfare gain from the saving in time. Despite their similarity, the EV has some technical advantages over the CV (Slesnick 1998, p. 2112).

could produce losers among noise-afflicted residents, while benefiting travellers.

But options for compensation can salvage the Pareto principle.

Say that the winners from a new airport would benefit by \$5 million while the losers would become \$1 million worse off. The net benefit, or 'efficiency gain', would be \$4 million. The net benefit being positive reveals an opportunity for creating a 'win-win' situation by combining the project with compensation payments. Travellers and other beneficiaries could pay the losers, say, \$2 million, leaving both groups \$3 million ahead. Indeed, a judicious system of compensation, in theory, could leave each individual better off. Whether a project can achieve this Pareto improvement after payment of compensation is the 'Hicks-Kaldor compensation test'.

A caveat: the Hicks-Kaldor test requires only that a project have the *potential* for a Pareto improvement when combined with compensation payments. To require that compensation *actually* accompany the project is a more stringent condition that may conflict with egalitarian concerns. What if the winners from a project are poor, while those to be compensated (the would-be losers) are rich?

Conversely, when a project would reduce economic efficiency, there are, in theory, better ways of helping the project's beneficiaries. Rejecting the project and compensating those who would have benefited could leave everyone better off, on balance. Thinking again of a bus service that would cater mainly to the elderly, the elderly could conceivably benefit more from assistance in some other form. What if most of the intended beneficiaries prefer to drive their own cars and are capable of doing so? The passenger volume might be too low for the service to be economically efficient. That would constitute a case for scrapping the bus service and possibly compensating would-be passengers with money.

The possibilities for compensation justify a healthy respect for economic efficiency as a BCA criterion. However, there may also be other criteria deserving consideration. For one thing, whatever the theory, compensation schemes accompany relatively few projects.

Even when compensation occurs, it never produces a purely winwin situation. Lack of information alone precludes the design of such a scheme. It is impossible to identify each winner and loser, much less to value their gain or loss exactly. The number of parties affected by a project is too large, the range of effects too diverse, and

information too scarce (box 1.1). Even the best attempt at a win-win compensation scheme would leave *some* people worse off.³

Then too, compensation schemes are not costless. In addition to the administrative burden, the funding arrangements can have undesirable side effects. For example, an increase in income tax rates to fund a compensation scheme could discourage work effort

BOX 1.1 THE WINNERS AND LOSERS FROM RURAL HIGHWAY BYPASSES — PROBLEMS IN IDENTIFICATION

Highway bypasses have diverse effects on rural towns.

Diversion of traffic from the town — especially heavy vehicles — makes for a safer and quieter environment. It also relieves local traffic congestion, where any had existed. In turn, these improvements can attract new business and residents to the town. For example, the historic town of Berrima in New South Wales drew more tourists as a consequence of being bypassed (BTCE 1994, p. 7).

But diversion of traffic from a town can also reduce business for local petrol stations and other traffic-serving establishments.

Some townspeople will benefit from these changes; others will lose out. To identify each winner and loser is impossible, except perhaps in the tiniest hamlet. How would one know, for example, the value someone attaches to the improvement in the town's environment? Someone who values this highly could be a winner, despite working in a petrol station that would lose business.

A bypass around one town can also affect other towns in the same region. Among tourists to Berrima surveyed after the bypass, some said that under pre-bypass conditions, they would have visited some other place. Yet whether nearby towns in the Southern Highlands gained or lost tourists was unclear. Tourist itineraries often include multiple stops and some of the tourists interviewed in Berrima mentioned stopping elsewhere in the Southern Highlands, including in Bowral and the Kangaroo Valley. For some tourists, the increase in Berrima's appeal may clinch their decision to visit the region, taking in both Berrima and other towns.

³ Compensation schemes also pose enforcement problems, particularly a scheme that spans many generations. Lind (1997) discusses the enforcement problems associated with schemes to compensate future generations for environmental damage.

and saving, thereby reducing economic efficiency.⁴ Chapter 7 examines the efficiency costs from taxes and other means of funding public expenditure. For more on the problems with compensation schemes, see Kasper (1999, pp. 17–20).

However, these are arguments for tempering the application of the efficiency criterion in BCA, not for discarding it. Even in the absence of compensation schemes, the efficiency criterion remains relevant. Landsburg (1993), referring to it as the 'cost-benefit criterion', gives two reasons for its popularity among economists. The first reason is pertinent to this discussion:⁵

First, if the cost-benefit criterion is applied consistently, then most people will probably gain more than they lose over the course of many policy decisions. This is so even though any particular application of the criterion can hurt good people in unfair ways. When we ban logging to confer a \$200 benefit on Jill at the cost of a \$100 loss to Jack, Jack can at least take comfort in knowing that we will side with him in future controversies where his potential benefits are large (Landsburg 1993, p. 104).

Other moral judgements, besides the Pareto principle, also inform some BCAs. Projects can affect both present and future generations, and judgements about intergenerational fairness enter some choices of discount rates (chapter 6).

Egalitarian sentiments may constrain the values imputed to certain benefits. Savings in non-business travel time are generally worth more to the affluent than to the poor. (The monetary sacrifice that people are willing to make to save time increases with their income.) So, to measure the efficiency gain from a project, the imputed value of non-business time savings should be higher for affluent travellers. The absence of such a distinction in BCA practice might be explained by measurement problems alone. Data on the socio-economic characteristics of travellers are scant for most transport projects, and the value that travellers, rich or poor, place on their time is hard to estimate (chapter 4). But even without measurement

⁴ The Hicks-Kaldor compensation test has also drawn other criticisms, some rather technical (like the possibility of Scitovsky reversals). Interested readers can consult texts such as Pearce & Nash (1981, pp. 27–31). Also recommended, though highly technical, is a survey article on welfare measurement by Slesnick (1998). He urges economists to confront moral questions 'head-on', rather than dodging behind the compensation test, which he regards as seriously flawed (Slesnick 1998, p. 2137).

⁵ The other reason mentioned was that economists are skilled at applying the cost-benefit criterion.

problems, some people would baulk at valuing time more cheaply for the poor.

The incorporation of egalitarian sentiments into BCA through distributional weighting systems has enjoyed some limited support among economists. Such weights assign a greater social value to benefits among the poor than among the rich. Squire & van der Tak (1975) favoured this approach, especially for developing nations, where, they argued, the distribution of income tends to be very unequal, and governments have limited ability to raise revenue for compensation schemes.

In practice, hardly any BCAs use distributional weighting systems. Determining the distribution of net benefits by income class is seldom feasible with the available data, and the choice of appropriate weights is tricky.⁶ In addition, there is the traditional bias among economists against mixing BCA with moral judgements.

Whatever moral judgements a BCA adopts, they should be transparent to all concerned. In particular, the analysis should be explicit about deliberate departures from an efficiency-based measure of net benefit.

Also desirable is information that helps people to evaluate a project, drawing on their own moral values. Such information could include, for example, the distribution of benefits and costs by income level or by region. The paucity of distributional evidence in many BCAs reflects, in large measure, the difficulty in obtaining it. An exclusive focus on economic efficiency, to the neglect of distributional issues, is not an inherent feature of BCA, despite some having defined it this way (Austroads 1996, p. 1). For example, a BCA of options for the Tasmanian railway system went beyond efficiency concerns, in considering the regional distribution of possible redundancies (BTCE 1991, pp. 89–90).

What about effects that cannot be valued in monetary terms?

Any BCA will fail to value some of a project's effects, and some of the omissions may be important. The information needed for credible valuations is often lacking. However, a good BCA does not simply ignore important effects for which monetary valuations are unfeasible. Where possible, it will estimate such effects in physical units. For

⁶ The difficulty in determining suitable weights is also an objection to multi-criteria analysis (chapter 13). Indeed, a BCA that includes income-distributional weights is arguably a form of multi-criteria analysis. Both these types of analysis emphasise criteria other than economic efficiency.

example, it may estimate the effect of a transport project on greenhouse gas emissions, without assigning these emissions a monetary cost (BTCE 1996b, p. 53).

For some effects, information may be inadequate for measurement in any units, whether physical or monetary. Even then, a BCA may yield some insights as to the direction of effect. Does local air quality suffer from urban expressways? Does it benefit from diversion of freight traffic from road to rail? If the answers seem obvious, see chapter 12.

The measurability of some effects is debated. Employment creation is an oft-claimed benefit from public investments in transport infrastructure. However, such investments can affect employment both positively and negatively through many complex channels. Chapter 5 considers whether the net effect can be estimated reliably.

Are national economic models needed?

BCAs of transport projects conventionally focus on transport outcomes when measuring benefits. For road projects, BCAs will measure the savings in road transport costs: the costs of vehicle operation, travel time and accidents. Some analyses also include an induced traffic benefit, as discussed in chapters 2 and 3.

Whether knowledge of transport outcomes is largely adequate for benefit measurement is a bone of contention. Some analysts consider it essential to have information on the broader outcomes of transport projects — the changes in export volumes, employment, industry prices, and so on. In particular, some have alleged that without taking account of such outcomes, the benefits of transport investments will be seriously understated.

For information on broader outcomes, people have turned to national economic models, including 'general equilibrium' models. Because the models are not used very much in BCA, some discussions refer to general equilibrium (GE) analysis and BCA as alternative frameworks. However, BCA, as conceived in this report, is not limited to particular modelling techniques; an analysis of the benefits and costs to society of some action can be a BCA, whether it uses GE analysis or not. Chapter 9 evaluates the potential contribution to transport BCA of national economic models (GE models included).

What are some other common criticisms of BCA?

Rural interest groups in Australia often complain about a lack of vision in transport BCAs. For many rural projects, the BCA indicates that future traffic volumes are unlikely to be high enough to warrant implementation. A common response from rural stakeholders is that the improvement to transport will attract industry to their regions, thereby increasing traffic sufficiently to make the project economically viable. Chapter 10 considers the substance of such arguments.

BCAs also draw criticism over their treatment of logistic adaptations to transport improvements. The benefits from changes to inventory and warehousing practices are often omitted or crudely measured. Chapter 11 explores the problems and the way ahead, drawing on chapter 4's discussion of time savings.

'Positive externality' has been a popular description, appropriate or not, for various benefits attributed to transport. The Australian Automobile Association (AAA), for instance, applied this term to 'the enhancement of exports, contributions to the balance of payments, and the flow-on savings to consumers, retailers and land developers' (AAA 1997, pp. 1356, 1362). It also expressed concern that 'normal benefit-cost analyses' do not capture positive externalities. Chapter 12 examines the reality and significance of this alleged failing, and whether macro-econometric analysis can remedy it, as some have hoped. Chapter 8, about imperfect competition, is useful preliminary reading.

How does BCA compare with other evaluation techniques?

BCA is only one of the frameworks used to assess transport projects.

A 'technical adequacy assessment' uses engineering-related criteria to identify portions of an infrastructure network that are deficient. The standards of technical adequacy are somewhat arbitrary (BTCE 1995a, p. 6). Moreover, unlike a BCA, such an assessment does not examine whether a project is economically warranted. In some cases, a technical needs assessment may reveal no deficiency, but an upgrading may be worthwhile. Conversely, parts of a transport network — such as the streets of an emerging ghost town — may have technical inadequacies that are not worth remedying.

McFarland & Memmot (1987) demonstrated the inferiority of technical adequacy assessment to BCA. Using each technique separately, they ranked a large sample of proposed highway construction projects in Texas. They then selected the highest-

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ranking projects fundable within a combined budget of \$5.7 billion. The projects selected by technical adequacy assessment would have yielded benefits of \$36.5 billion, as estimated by the BCAs of the same projects (McFarland & Memmot 1987, p. 1116). In comparison, the projects selected by BCA would have yielded benefits estimated at \$59.2 billion, or about 60 per cent more than the projects selected by technical adequacy assessment.

Although inferior to BCA, technical adequacy assessment can play a complementary role. It is easier to conduct than BCA, which is data-intensive and time-consuming. Moreover, the identification of a serious inadequacy by technical standards will often suggest projects for which BCA is especially needed

A 'cost-effectiveness analysis' (CEA) takes an objective as given and looks for the lowest-cost means of attaining it. It does not attempt to value the benefits of meeting the objective. Where valuations are unfeasible, the use of CEA may be defensible. But people may also turn to CEA even when the benefit valuations are feasible, simply to avoid the embarrassment of a low benefit–cost ratio. For example, this has partly motivated the use of CEA for rail transit investments in US cities (chapter 13).

A 'multi-criteria analysis' (MCA) is hard to define, but what goes by that name is usually a far cry from conventional BCA. As chapter 13 explains, MCA can open the door for arbitrariness, subjectivity and self-interest.

Some other evaluation techniques are simply variants of BCA. For example, the differences between conventional BCA and Total Cost Analysis (De Corla Souza et al. 1997) are basically presentational.



2

ARE INDIRECT BENEFITS MEASURED?

Improvements to transport can induce various adaptations beyond transport; for example, a business may adjust to lower freight costs by expanding output or managing inventory differently. The benefits that result from such adaptations are the 'indirect' benefits of transport projects.

BCAs tend to measure indirect benefits obliquely, inferring their magnitudes from transport outcomes. The inferences are subtle, people sometimes fail to understand such measures and then criticise a BCA for ignoring indirect benefits altogether. The critics often want to supplement the analysis with less oblique measures of indirect benefits, even though double counting of benefits will usually result.

Critics also tend to exaggerate the importance of indirect benefits. There are often preliminary indications that a claimed indirect benefit is minor. Such benefits may not even warrant the trouble of estimation. Estimating only the main costs and benefits can make perfect sense in a BCA, given that resources for the analysis are always limited. The following example explains how indirect benefits can be measured from transport outcomes and why they are often minor.

THE BENEFIT FROM INDUCED TRAFFIC

Consider a road upgrading that would increase tourism from Brookville to Gladesburg, two imaginary towns. The upgrading would improve fuel economy and reduce vehicle wear and tear (by widening the road or smoothing its surface). It would also reduce travel time. For the present, suppose that the improvements only affect the tourists; chapter 3 considers the broader effects of improvements to tourist transport. A BCA is used to estimate the benefit during each of various years. The estimate for the year 2010 is based on the figures in table 2.1. The transport cost per trip includes a notional cost of travel time, consistent with the willingness of the tourists to sacrifice some amount of money to reach their destination faster.

TABLE 2.1TOURIST CAR TRIPS FROM BROOKVILLE TO
GLADESBURG, TRAFFIC AND COST, YEAR 2010

Standard of the Gladesburg-Brookville road	Transport cost per round trip	Trips per year
Current	\$50	3,000
Upgraded	\$45	3,300

Cost savings on existing traffic

The tourists would make 3,000 trips in the year 2010, were the road to remain at its current standard. Upgrading the road would reinforce the decision to take these trips because travel costs would decline. The cost savings on this 'existing traffic' would total \$15,000 (= $3000 \times ($50-45)$).

INDUCED TRAFFIC BENEFIT AND THE 'RULE OF HALF'

The upgrading would induce an increase in tourist traffic of 300 trips. For each induced trip, the tourists must expect benefits to outweigh costs; otherwise they would not be going. Hence a lower bound on the net benefit from an induced trip is zero.

An upper bound on the net benefit from an induced trip is \$5 (\$50-\$45), the saving in trip cost due to the upgrading. The net benefit cannot be any larger. Why? Because if it were any larger, the tourists would already be making the additional trips without the inducement of the upgrading. If the net benefit from taking a trip on the upgraded road were, say, \$8, then the same trip on the current road would provide a net benefit of \$3. Counting such trips as 'induced' would be a classification error; they would really be part of existing traffic.

Most BCAs estimate the induced traffic benefit with the 'rule of half': they average the lower and upper bounds to estimate the net benefit

per induced trip.⁷ Since the lower bound is zero, the average equals half the upper bound. In the present example, the estimated net benefit per induced trip would be \$2.50 (half of \$5). The estimated net benefit from all induced trips would equal \$750 (=\$2.50 x 300).

More precise measurement of the induced traffic benefit would require additional information. Table 2.1 indicates the number of trips people want to take — the 'demand' for trips — at only two levels of cost per trip: \$50 and \$45. These are the levels that would prevail with and without the upgrading. A complete 'demand curve' would also show the demand for trips at intermediate levels of cost, such as \$47.

Figure 1 shows the measurement procedure given full information about demand. The cost savings for trips already being taken on the existing road (existing traffic) equal the rectangular area P_0P_1JH . As measured by the rule of half, the benefit from induced traffic equals the triangular area HJK; this equals (P_0-P_1) (Q_1-Q_0) x $\frac{1}{2}$. More precisely measured, the induced traffic benefit equals the quasi-triangular area bounded by the line segments HJ and JK, and by the demand curve. One can derive the more precise measure as follows: decompose the price reduction into a large number of stepped reductions, then apply the rule of half to estimate the benefit from each stepped reduction. Summing the benefits from each stepped reduction is tantamount to using the more precise measure (Sugden & Williams 1978, pp. 113–118).

Road BCAs rarely use the more precise measure because the exact form of the demand curve is hard to determine. Depending on the type of curvature, the more precise measure can be either larger or smaller than the benefit implied by the rule of half. If the demand curve is a straight line, the two measures will be identical. The assumption of a straight-line demand curve is natural in the absence of information about curvature.

An induced traffic benefit can measure the benefits from various responses to a transport improvement. Each response entails increased use of the transport that has improved: increased tourism along an upgraded road; usage of additional transport to reduce inventory costs; expansion of farm industries that gain better port access; and so on.

⁷ Some BCAs simply use the upper bound, a practice noted by Kinhill, Cameron & McNamara (1992, p. 44) and rejected by Austroads (1996, p. 11). Overestimation of the induced traffic benefit results from this practice.



The induced traffic benefit measures a gain to society. When farmers expand production upon gaining better port access, the induced traffic benefit will reflect the increase in farmers' profits plus benefits and costs to other affected parties, such as the farmers' customers (as discussed in chapter 3).

Some may wonder how transport information alone can measure the benefits from induced responses. If a transport improvement induces additional farm production, the benefits from this response would depend on farm output prices, input costs and other variables outside transport. But the expansion of production would depend on the increased use of transport. Hence the benefit from the expansion would be indicated by how much people are willing to pay for the extra transport; this, in turn, would be revealed by the relevant demand curve.

The encapsulation of so much information in demand curves for transport permits enormous savings in BCA effort. A transport infrastructure facility can serve many categories of users — wheat farmers, car manufacturers, tourists, government agencies, and so on. Investment in the infrastructure might induce each category of user to respond in ways that involve more trips. Imagine trying to estimate the resulting benefits by collecting, for each category of user, detailed information beyond transport (such as the input and output prices facing the wheat farmers). The task could be enormous. The alternative of measuring an induced traffic benefit limits the required information to the relevant demand curve for transport. This task, while also difficult, is much more feasible. Relatively simple methods can often provide some idea of the amount of induced traffic, which is the key information required about demand (box 2.1).

BOX 2.1 ESTIMATION OF INDUCED TRAFFIC — SOME EXAMPLES

Asking people about their intended use of a transport facility is one way of estimating induced traffic. Access Economics (1990) used this approach for a proposed high-speed rail link between Sydney and Melbourne via Canberra. They asked travellers to estimate the number of additional trips that the rail link would induce them to make.

Alternatively, one could estimate a model of transport demand using historical data. Such a model predicts the amount of traffic that will be induced by a reduction in transport costs. Evaluations of transport investments (for example, BTCE 1997a) often use rules of thumb that are derived from these models.

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THE CONCEPT OF CONSUMER SURPLUS

The more precise measure of induced traffic benefit, when added to the cost savings on existing traffic, yields a measure of total benefit. In figure 1, it equals the quasi-triangular area HJK (induced traffic benefit) plus the rectangular area P_0P_1JH (cost savings on existing traffic). The full name for this measure is the 'change in transport consumer surplus' (CTCS). The approximation to the CTCS using the rule of half is most exact when the demand curve resembles a straight line.

Consumer surplus can also be measured for goods and services outside transport. The change in consumer surplus indicates a welfare gain or loss due to a change in the cost of some good or service. For example, an import tariff reduces consumer surplus by raising the cost of imported goods. One could measure this loss with knowledge of the relevant demand curve.

DO INDIRECT BENEFITS MATTER MUCH?

In the above example, the benefit from increased tourism is relatively minor. Approximated with the rule of half, it amounts to only 5 per cent of the cost savings on the existing tourist traffic (\$750/\$15,000; table 2.1). It would be even less significant relative to the total benefits of the road upgrading, including benefits relating to non-tourist traffic (not calculated in this example).

The benefit from increased tourism is relatively insignificant in the example partly because the reduction in trip cost is modest (10 per cent). A small reduction in cost is a small inducement to travellers, unless travel propensity is highly cost-sensitive. In table 2.1, each one per cent reduction in trip cost induces 1 per cent more tourist trips. In other words, the *cost elasticity of demand* equals –1.0. The elasticity of demand would have to be much larger (in absolute value) for the induced tourist benefit to matter much. Available evidence suggests that the elasticity is usually not that large. For car travel on Australian rural roads (not just among tourists), a typical cost elasticity might be about –1.08, according to a review of the evidence by Bowyer & Hooper (1993, p. 235).

More generally, the indirect benefits of transport investments are often minor. In countries like Australia, many of the projects analysed in BCAs are modest additions to an already well-developed transport network. Such projects reduce the cost of transport by only a small proportion.⁸ The increase in transport demand will also be marginal, unless demand is highly cost-sensitive.

IN SUMMARY

- The indirect benefits of transport projects stem from various responses to the improvements in transport. Examples of such responses are changes to inventory management and expansion of output.
- BCAs make allowances for these benefits that are often subtle, being based on transport outcomes. To add to such allowances alternative measures of the same benefits is a common form of double counting.



⁸ Traffic congestion can also limit the reduction in transport cost. The responses that produce the indirect benefits, such as changes to inventory and warehousing practices, tend to generate traffic. The resulting increase in congestion adds to transport cost. Some BCAs include the induced congestion cost in their estimates — see, for example, BTCE (1995, appendix II).

3

ARE TRANSMITTED BENEFITS INCLUDED?

The benefits of a transport investment can spread in various directions through changes in prices.

They can spread along a vertical production chain, with producers at each reducing prices for their customers but still coming out ahead. Suppose that freight costs decline for cotton lint. The beneficiaries could include the cotton farmers, textile producers and clothing manufacturers; they could also include parties further downstream, such as industrial users of cotton uniforms.

Likewise, benefits can spread along horizontal chains and so can disbenefits. A reduction in cotton freight costs would reduce the demand for cotton substitutes, adversely affecting the producers of those substitutes.

The conventional framework for BCA includes such transmitted benefits and disbenefits. The following examples highlight this fact, focussing on the CTCS measure of benefit (described in chapter 2). The first example relies on assumptions of perfect competition, and covers rather basic ground in economics. The second example introduces imperfect competition, which chapter 8 explores further. Both examples abstract from taxes, externalities and national boundaries, which are discussed later in this report.

EXAMPLE A: TRANSMISSION OF BENEFITS FROM REDUCED FREIGHT COSTS

Transmission of benefits from producers to consumers

Suppose that freight costs decline for some commodity and that the only beneficiaries are the producers of the commodity and household consumers. This is the simplest case of a vertical production chain. One could imagine that the producers sell directly to household consumers or, more realistically, that intermediaries pass on all the cost savings.

Figure 2 depicts the effects of the reduction in freight cost. The vertical axis measures the delivered price of the commodity to consumers. The supply curve SS shows the quantity of the commodity that producers wish to supply at any given delivered price, with freight costs at their original level.



When freight costs decline, producers earn more revenue at any delivered price. So the supply curve shifts down by a distance equal to T, the decline in freight cost per unit of output. This reflects an accounting identity: from the perspective of producers, the price equals the delivered price minus unit freight cost.⁹

The price that prevails in the market is P_0 before the freight improvement and P_1 after. Producers can each sell as much as they want at that price and consumers can each buy as much as they want. This is the equilibrium situation under perfect competition, a paradigm that approximates conditions in some actual markets (especially in agriculture).

The freight improvement reduces the prevailing delivered price by an amount $P = P_0 - P_1$, which benefits the customers. The producers benefit as well, with their price increasing by the amount (T - P) > 0. Further, the quantity produced (and consumed) increases from Q_0 to Q_1 .

The induced increase in production would add to freight traffic. So could other responses to the freight improvement, such as changes to inventory practices. The present example omits these other responses for ease of exposition, making the amount of traffic proportional to the level of output. This allows measurement of traffic in units of output (horizontal axis, figure 3).

Measurement of benefits

Consumers benefit from the reduction in delivered price by an amount equal to the change in consumer surplus, the sum of areas A and B in figure 2. (Chapter 2 explains the concept of consumer surplus.)

Similarly, producers benefit from the increase in their price by an amount equal to the change in 'producer surplus', the sum of areas C and D. Area C equals the revenue gain to producers on their existing level of output. (The height of the rectangle C is the increase in the producers' price.) Area D equals the net benefit to producers from increasing output (from Q_0 to Q_1). The interpretation of area

⁹ To explain the shift in the supply curve in more detail:

If a decline in unit freight cost were entirely passed on to consumers through an equal decline in the delivered price, producers would receive the same price as before. Hence the producers would continue to supply the same amount of the commodity. Accordingly, when the unit freight cost declines by T, the supply curve shifts down by a distance equal to T.

D entails the same ideas that were used to explain the induced traffic benefit in chapter 2. In particular, the net benefit to producers from each extra unit output cannot exceed the increase in the producer price, T- P. (Otherwise, it would already have been worth the producers' while to supply the extra output at the old price.)

The CTCS (figure 3) includes all the benefits to consumers and producers of the commodity. The cost savings on existing traffic (area E) depend on such factors as improvements in fuel economy



and the price of fuel. None of these factors change when the price of the transported commodity declines; some benefits merely transfer from producers to consumers. Thus the benefits to producers and consumers on the existing level of output (areas A and C in figure 2) sum to the cost savings on existing traffic (area E). The other component of the CTCS, the induced traffic benefit (area F) equals the benefits to producers and consumers from the induced increase in output (the sum of areas B and D in figure 2).

The CTCS would still measure total benefits, were there sources of induced traffic other than increased production, unlike in this example. Ignoring the other sources merely simplified explanation, as did drawing the demand and supply curves as straight lines.

More complex transmission of benefits

Adding further links to the vertical production chain would be straightforward. The only beneficiaries in the preceding example were household consumers and the producers of the commodity for which freight costs declined. Additional diagrams, like those in figures 2 and 3, could represent the effects on other vertically related beneficiaries. One could show with such diagrams that the CTCS measures the total benefit to all parties. One could also show this to be the case when benefits (or disbenefits) are spread through horizontal economic links. Just, Hueth & Schmitz (1982) corroborate both these claims mathematically. (For a simpler but less general exposition, see also Jara-Diaz 1986.)

Note: Bad estimates of the CTCS will not approximate the benefits from a road improvement, even under perfect competition, and there are many sources of estimation error, such as inaccurate projections of traffic.

EXAMPLE B: TRANSMISSION OF BENEFITS FROM IMPROVED TOURIST TRANSPORT

The CTCS best measures benefits for hypothetical economies with perfect competition (see example A above). Applications to real economies contain errors because of imperfect competition. Some commentators have suggested that the errors are serious, though without providing evidence (for example, Austroads 1997a, p. 102). In reality, the nature of the errors will depend on the particular improvement in transport being evaluated. In many cases, they are likely to be minor because competition throughout much of the Australian economy is keen.

Inadequate competition in the tourist industry?

Consider, for example, improvements in tourist transport. Competition in the tourist industry, while never perfect, is usually stiff. A major resort town will have many restaurants and hotels vying for business. Small towns with few such establishments will nevertheless face competition from tourist establishments elsewhere.

Product differentiation, it is true, somewhat limits competition in tourism, as in other sectors. Restaurants differ in location, decor, the skills of the chef, and in other product dimensions. The product differentiation insulates each restaurant against competition to some degree: each can raise its prices to some extent without losing all its customers. This is unlike perfect competition, where the product is homogeneous and producers cannot charge more than the prevailing price. Product differentiation may confer significant monopoly power on pockets of the tourist industry. A theme park, for example, may derive such power from highly distinctive attractions as well as distance from competitors. But in many segments of the tourist industry, perfect competition is probably not too far from the truth. Product differentiation confers on each producer only a modicum of monopoly power. A restaurant may offer distinctive meals or a convenient location, but there are usually close enough substitutes to sensitise customers to differences in menu prices.

Measurement of benefits from improved tourist transport

Imperfect competition can impart both positive and negative errors to the CTCS measure of benefit. Whether benefits are over- or under-estimated will vary between projects.

Strengthening of competition

Improvements to transport bring producers in different locations into closer competition. However, the benefits from the increased competition may not show up in the CTCS.

For illustration, consider the upgrading of a road that serves Brookville and Gladesburg, two imaginary towns. In each town, visitors to tourist attractions include some of the town's residents, but these locals tourists do not travel along the upgraded road.

Imagine now that the tourist industry is perfectly competitive in Brookville, and monopolistic in Gladesburg. The upgrading of the road exposes the tourist industry in Gladesburg to greater competition from Brookville. So a plausible scenario runs as follows:

As a result of the upgrading, the industry in Gladesburg loses some of its monopoly power and reduces its prices (one could reasonably assume). At the lower prices, local tourism by Gladesburg residents increases. This provides an additional benefit to what the CTCS measures. A benefit arises because the monopoly, with its high prices, had kept local tourism in Gladesburg to a socially suboptimal level. The benefit does not show up, however, in the CTCS. The CTCS relates only to the traffic on the upgraded road to Brookville; it includes the benefit from induced traffic on the road, plus the cost savings on existing traffic. Because local tourists in Gladesburg do not travel this road, the benefit from the increase in local tourism is additional to what the CTCS measures.

Effects on tourist industry profits

The omission of benefits from intensification of competition is but one of the errors in the CTCS that could stem from competition being imperfect. In combination, the various errors could cause the CTCS to either overstate or understate the benefits from an improvement in tourist transport. Much depends on where the tourist industry is more competitive — within the present example, in the towns that gain tourists as a result of the road upgrading, or in competing tourist destinations. To simplify matters, suppose now that only one town gains tourists, say Brookville, and that its gain represents a diversion of tourism from elsewhere.

In the extreme case where the tourist industry is perfectly competitive in Brookville and has strong monopoly power elsewhere, the CTCS might overstate benefits (see Schmalensee 1979 or Mohring & Williamson 1969, p. 257).

A key difference between perfect competition and monopoly helps to explain.

Monopolists have latitude in setting prices, at least in the absence of regulation. Moreover, at the price they find most profitable, they will attract less business than they want (as the standard theory of monopoly predicts; see, for example, Krebs 1990, pp. 299–324). A tourist business with monopoly power — say, a unique theme park — could therefore benefit from the extra business that results from an improvement in tourist transport, even if prices were to stay the same.

The assumptions of perfect competition, on the other hand, exclude this possibility. Businesses offer identical services, and can sell as much as they want at the prevailing price for these services. An

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improvement in tourist transport could then benefit local businesses only by increasing prices for their services. Since the CTCS approach presumes perfect competition, it ignores any additional benefits that would accrue to local businesses from increased volume. Similarly, it ignores any additional losses to businesses in competing tourist destinations from reduced volume. In the extreme case being considered, the additional benefits on increased volume are absent because the tourist industry is perfectly competitive in Brookville, where the industry expands. But the monopolistic tourist operators elsewhere suffer losses that the CTCS would fail to reflect.

Another way of explaining the implications of monopoly is to note the effect of market power on profits.

Perfect competition keeps profits down to normal levels. An industry that is perfectly competitive may earn windfall profits for a while: for example, after an unexpected increase in demand. But industry profits would eventually return to normal levels, as supply increases in response to the supernormal profits.

An unregulated monopolist, in contrast, can maintain high prices and profits by limiting supply. If the tourist industry is perfectly competitive in Brookville and monopolistic elsewhere, the profits per additional tourist are likely to be relatively low in Brookville. A transport improvement that redirects tourism to Brookville will, in this respect, reduce total profits from tourism. The loss of profits is a cost to society, that the CTCS would not reflect. Conversely, if the tourist industry were monopolistic in Brookville and competitive elsewhere, the redirection of tourism would increase total profits. The CTCS would then understate benefits.

IN SUMMARY

- An improvement to transport can have benefits that spread far beyond the transport sector. The conventional framework for measurement in BCA reflects such transmitted benefits.
- Conventional measures of benefit will contain errors arising from imperfect competition. But with competition through much of the Australian economy being keen, the errors are likely to be minor for many transport projects. The overall impact (positive or negative) of the errors will vary between projects.
4

HOW ARE TIME BENEFITS VALUED?

The valuation of time savings is a crucial task in most transport BCAs. In the vast majority of road BCAs, time savings account for most of the estimated benefits — often, as much as 80 per cent (Waters 1995, p. 1). For many non-road projects, time savings are also a major benefit category. Practices for valuing time savings vary considerably, and have sparked much debate.

The randomness of trip times complicates the task of valuation. Trip times can be quite unpredictable because of congestion, accidents, break-downs of infrastructure or equipment, or other circumstances (such as flooding). Investments in transport can reduce the severity and frequency of these circumstances, and many users of transport infrastructure value predictability greatly. For example, freight forwarders emphasise predictability, when asked about the importance of various aspects of rail service quality (see, for example, BTCE 1997b). Unpredictable delays inconvenience them directly, as by making their truck wait at the rail terminal and by disappointing their customers. For the customers, delays can disrupt production, jeopardise sales and increase the need for buffer stocks.

Despite some progress (for example, Wigan et al. 1998), the measurement of predictability benefits remains a major challenge for transport BCAs. Many BCAs ignore the element of randomness and focus on average trip times, since predictability is hard to measure, much less value. In road BCAs this is the norm.

PRACTICES IN ROAD EVALUATIONS

In general, BCAs of road investments distinguish an hourly value of time for each of several categories of travel. The primary distinction is between classes of vehicles, such as cars, rigid trucks and articulated trucks. For cars, the analyses also consider the purpose

of travel: Austroads (1997b) recommended values for non-business travel that are only 40 per cent of the values for business travel. In practice, the composition of car traffic by purpose is unknown for most roads, although it has been estimated for broad categories of roads (especially urban versus rural).

Road BCAs in Australia use values of time that are generally consistent with the Austroads (1997b) recommendations. The harmonisation of procedures has helped, but several issues remain contentious or unresolved.

Valuation of small time savings

Standard practice in BCA would assign the same benefit to:

- (a) a five minute saving on each of forty trips and
- (b) a forty minute saving on each of five trips,

since the total amount of time saved is the same (200 hours).

A common objection to this practice is that people have trouble making use of, and may not even perceive, mere minutes saved from a trip. Some have recommended on this basis that BCAs should value time at a lower hourly rate for small reductions in trip time. In the above example, this would mean a lower hourly rate for (a) than for (b).

Austroads (1997b, p. 8) found that some Australian States were assigning zero values to small savings in trip time. This may have increased the average BCR for rural investments relative to urban ones: time savings per trip are said to be typically smaller for urban investments (Button 1993, p. 57; Kinhill, Cameron & McNamara 1992, p. 23).

Such departures from standard practice are hard to defend. Rigidities in schedules cause the value of time to increase with the amount of time saved only in some situations. In other situations they have the opposite effect (box 4.1). Driving habits reveal that people value even a few minutes off a trip; many drivers risk serious accidents for savings of only seconds (by weaving between lanes, for instance). Among commuters, couriers and other groups, some travellers face such tight schedules that they *do* notice even minutes saved. Moreover, people can benefit from time savings that they do not perceive.

Furthermore, research on how the value of time varies with the amount of time saved has been problematic. One complication is

BOX 4.1 RIGID SCHEDULES AND THE VALUE OF TRAVEL TIME SAVINGS

John has a rigid work schedule which ends at 5 pm. From work, he often drives to a film screening that starts at 5:30, but the travel time of 35 minutes causes him to miss the first five minutes of the film. He would be willing to pay \$1 for a five minute saving in travel time to get to the cinema on time. This equates to a value of time of \$12 per hour. A larger saving in travel time would only get him to the cinema a bit early or leave him with time to kill at the office, and he doesn't particularly mind spending time driving. Hence he would be willing to pay only slightly more, say \$1.20, for a 20 minute saving in travel. For John, the value of time per hour thus decreases from \$12 to \$3.60 as the time saving increases from five to 20 minutes. The contention that the value of time increases with the amount of time saved is invalid for him, as for many other travellers.

that a person might value the same reduction in trip time quite differently, depending on the initial length of the journey. For example, as a commuter's trip lengthens, each minute added to the trip may seem more onerous than the last. Yet the influence of the initial journey length was ignored by Thomas & Thompson (1971), whose estimates gained acceptance in a widely used manual for analysing US highway improvements (AASHTO 1977). In their estimates, the value of car time increased with the amount of time saved. For work trips, the implied value of time was \$0.48 per hour for savings under five minutes, versus \$3.90 per hour for savings of more than 15 minutes (AASHTO 1977, p. 17). More recently, Small (1992, p. 38) observed that a few studies have reported vast differences in values of time for different amounts of time savings, but that the evidence is flawed.

Without considering journey length, the use of different values of time for different amounts of time savings can produce nonsense. The benefit from an hour's saving in trip time is the same, whether it results from one large road investment or from a series of investments that each save a few minutes. The use of different values of time for different amounts of time savings, without considering journey length, contradicts this common sense. If the assumed value of time increases with the amount of time savings, the estimated benefit from an hour saved is larger when it results from one large investment than from a series of small ones. For further discussion of the value of travel time, see BTE (1982), Waters (1995) or Small (1992).

Validity of the generalised cost approach

BCAs of road investments measure a total, or 'generalised', cost per trip. The term 'generalised' signifies the inclusion of certain imputed costs, principally those of travel time. The costs of travel time are combined with the costs of other inputs like fuel and vehicle maintenance.

A problem with the generalised cost approach is that improvements in travel time effectively turn transport into a different good. Strictly speaking, the benefits cannot be measured off the demand curve for the 'old' good. In some cases, the generalised cost approach therefore may produce unreliable estimates of the benefits from induced traffic (box 4.2).

BOX 4.2 THE GENERALISED COST APPROACH AND THE INDUCED TRAFFIC BENEFIT

Susan takes a long and hectic drive to another town on business twice a week. A road investment makes the trip shorter and less stressful. Susan then accomplishes more on each trip, being more relaxed on arrival and having more time available before having to return home. And with each trip more productive, she finds that the two weekly trips can be reduced to one.

In this scenario, a beneficial response to a road improvement reduces demand for road transport. This would wrongly appear as a disbenefit (a negative induced traffic benefit) under the generalised cost approach. One could contrive counter examples where the generalised cost approach overstates the benefits from induced traffic.

Despite this limitation, the generalised cost approach is defensible for most road BCAs. As a rule, more accurate approaches are unlikely to be worth the added analytical effort. For further discussion of the generalised cost approach, see Button (1993, pp. 85–89), who reaches similar conclusions about its usefulness.

Valuation of savings in business travel time

Austroads (1997b, p. 10) recommended valuing business travel time as follows:

value of time = wage + labour overhead costs - payroll tax

For freight vehicles and buses, the recommended wage measure is the relevant award rate for the crew; for business car travellers, it



is average hourly earnings economy-wide. Overheads include superannuation contributions, workers' compensation levy and leave loadings.

However, payroll tax should be added to, not deducted from, the other components of labour cost (box 4.3). The error is nontrivial, with payroll tax having amounted to about 7 per cent of wages in 1995 (Austroads 1997b, p. 12). In theory, the value of business travel time should also include certain other taxes (box 4.3 explains), although such adjustments may be impractical.

Valuation of time savings for freight vehicles

Time savings for freight vehicles have benefits beyond the savings in crew costs. With trip time reduced, each vehicle can run more trips per year, so that fewer vehicles are needed for the same transport task. This means savings in capital costs of the vehicle fleet, a benefit that many road evaluation models, including the BTE's Road Infrastructure Assessment Model (RIAM), allow for.

Harder to estimate are the convenience benefits from faster delivery of freight. These include less damage to freight in transit, lower requirements for buffer stocks, and increased scope for timesensitive operations (meeting a rush order, for example). Estimates of the value of such benefits are scarce.¹⁰ The estimates cited by Austroads (1997b, p. 11) are large: the estimated convenience benefit of an hour saved exceeds the hourly operating cost of the vehicle. However, these estimates are based on European, not Australian, data. Another reason for caution is the lack of information on the reliability of the estimates. The BTE could only ascertain that they were based on stated preference analysis, a method that requires great care in application (as discussed below).¹¹

In deriving time values for Australian use, Austroads assumed that the convenience benefit from an hour saved equals 25 per cent of the hourly operating cost. The choice of 25 per cent was arbitrary.

¹⁰ A reduction in freight trip time also means a smaller stock of inventory in-transit. Given data on the value of freight, estimation of the resulting savings in inventory costs is straightforward. All one needs is a suitable choice of interest rate. BCAs that have estimated these savings include, for example, analyses of the cargo facilities at the Port of Darwin (BTE 1975), and of a rail freight terminal at Acacia Ridge (BTE 1974). However, for many transport projects, particularly road projects, data on the value of freight are scarce.

¹¹ Thoresen (1996, p. 33) flags possible problems with these studies. The BTE was unable to obtain from Austroads complete references to any of these studies, much less copies of them.

BOX 4.3 TAXES AND THE VALUE OF BUSINESS TRAVEL TIME

Consider a saving in travel time that reduces the crew requirements for some trucking operation by one worker. As a result, someone who would have driven a truck does other work instead. From the societal perspective, the benefit from the travel time saving is the value of the worker's output in the alternative employment.

To measure this benefit, BCAs normally make two assumptions:

The value of the worker's output to an employer equals what the worker costs the employer.

This assumption is somewhat conservative, because employers usually benefit from their workers. That is, the value of a worker's output to the employer tends to exceed what the worker costs the employer. However, competition for a worker's services limits the size of this difference, since the value of these services will be similar across many workplaces. A worker who is paid much less than this value is likely to receive a better offer from another employer.

To take another angle, an employer can often find many workers with similar skills. As the employer takes on more of these workers, the value of each additional worker tends to diminish. The employer stops expanding his workforce when the expected value of an additional worker is less than cost. This suggests that the expected value of the last worker hired is not far above the cost.

The cost of employing the worker equals the cost of employing a truck driver.

In other words, the worker gets the same pay, whether driving a truck or doing other work. The assumption may be a tad optimistic: someone who would have driven a truck may earn less in alternative employment. However, this optimistic bias is offset by the conservative bias in the first assumption (above).

In combination, the above assumptions imply that the value of the worker's output to the employer equals the cost of employing a truck driver. Since payroll tax is part of the cost of employing a truck driver, the Austroads (1997b, p. 10) recommendation to deduct it is both puzzling and wrong.

Taxes on goods and services are also relevant to valuing business travel time. Suppose that the worker who would have driven a truck now works in a vineyard instead. The worker contributes to wine production, which attracts an excise tax. From the employer's perspective, the value of the worker's contribution is net of excise tax. However, the revenue from the excise tax provides a benefit to society: the government can use it to fund more services or to reduce other taxes. From a societal perspective, therefore, the value of the worker's output equals the value to the employer plus the tax revenue. As discussed above, the value to the employer equals the total cost of employing a truck driver, under certain simplifying assumptions. In principle, one should add the tax revenue, in order to fully value the worker's contribution to production.



Austroads implies that the European findings support a figure this large, while acknowledging the difficulty in generalising to Australia.

The Austroads allowance for convenience benefits can significantly affect the results of a road BCA. In RIAM, it accounts for over 35 per cent of the estimated benefit from an hour of truck time saved. (Savings in crew, fleet capital and vehicle operating costs account for the remainder.) Given the quantitative significance of the Austroads allowance, replacing it with something more reliable would be highly desirable. This should be feasible with additional research using Australian data.¹² Recent research sponsored by Austroads has taken a first step in this direction (see Wigan et al. 1998). Extensions to this research are planned.

Valuation of time savings for non-business travel

BCAs normally value non-business travel time at some proportion of average hourly earnings. The practice is sensible (box 4.4), but determining the right proportion is difficult. Austroads (1997b) recommended, with little explanation, using 40 per cent of average full-time hourly earnings. The recommendation appears to derive largely from overseas precedent. The UK, New Zealand and British Columbia chose 40 percent, after reviewing the international literature on travel time valuation (Austroads 1997b, p. 5; Waters 1995, p. 15). The US Federal Highway Administration makes a more generous allowance, taking 60 per cent rather than 40 per cent of some wage-related measure.

Inevitably, there is considerable arbitrariness in these rules. Most studies of the value of non-business travel time have focused on commuting (which, being unpaid, counts here as 'non-business' travel.) Even for this one category, estimates of the value of time vary substantially relative to the average wage. Waters (1995) examined estimates from various countries. For car commuting in North America, the estimates ranged from 12 per cent to 170 per cent of the average wage. The smaller number of Australian studies of the value of commuting time also exhibited substantial variation.

¹² Hodgkin & Starkie (1978) used data on transport of freight from Perth to the mining districts of northwest Australia. They estimated the value attached to time by analysing freight forwarders' actual choices between road transport and a slower mode, sea transport. Their estimates are of little value today, given the datedness of the analysis and the focus on a narrow segment of the freight market.

The central tendency of the estimates appears to heavily influence choices of values of time for BCAs. This is not the best basis for choosing, since the studies producing the estimates differ in reliability, currency and the representativeness of their samples. Conceivably, the most valid estimates could fall outside the central tendency. In practice, it is difficult to determine which estimates are the most valid, but further research could provide clearer guidance.

BOX 4.4 THE INFLUENCE OF EARNINGS ON THE VALUE OF NON-BUSINESS TRAVEL TIME SAVINGS

A saving in non-business travel time — typically taken to include commuting time because it is unpaid — is often convertible into longer work hours. In particular, commuters whose travel time declines can sometimes devote the time saved to work. The potential earnings from an hour worked thus influence the value of non-business travel time.

Other influences complicate the picture. For instance, someone might find commuting time more pleasant than time at work. When that person devotes savings in commuting time to work, the benefit is less than the extra earnings, the difference being the loss of enjoyment from working rather than commuting. If, on the other hand, the person found working and commuting equally pleasant (or unpleasant), the benefit would simply be the extra earnings (gross earnings, because income tax revenue from one person benefits the rest of society).

Earnings remain an influence when time saved is devoted to 'leisure' (activity outside paid work). Consider the case of Sally, who can work the number of hours she wants at a fixed rate of pay, say \$20 per hour. Sally faces a marginal tax rate of 35 per cent, so she would sacrifice \$13 net of tax by working an hour less. She also finds time commuting and working equally pleasant (or unpleasant). A transport improvement reduces her weekly commuting time by an hour, which she devotes to leisure. The value of the time saving to Sally is somewhat less that \$13. Why? Because even without the transport improvement, Sally could have gained an hour's leisure at a cost of \$13, simply by working an hour less. Because she chose not to do this, she evidently values an extra hour of leisure at somewhat less than \$13.

Earnings can also influence the value of time savings for travel by the nonemployed. For example, earnings affect income during retirement, which affects the value that the elderly place on their travel time. Someone retired on \$50,000 per year would probably value savings in travel time more than would someone on \$20,000 per year (as indicated by willingness to pay).



PRACTICES IN RAIL EVALUATIONS

Time-related benefits pose a challenge for BCAs of rail projects, as they do for road BCAs. In particular, how does one value the convenience benefits to customers when journey times become shorter or more predictable? (For that matter, how does one value other aspects of customer convenience, such as reliability of handling?)

Modal diversion adds a special twist to the analysis of convenience benefits from rail projects. Traffic diverted from other modes of transport can account for much of the traffic on new or upgraded railways. The rail service that is adopted may offer a significantly different, and sometimes inferior, level of convenience from the abandoned mode. In contrast, modal diversion is generally a minor issue in road BCAs (chapter 12).

Convenience benefits from improved rail passenger services

Hensher (1997) analysed the value of convenience for travellers along the Sydney–Canberra corridor. The purpose was to determine the market potential for a high-speed rail (HSR) service. The market potential depends largely on how the HSR would compare with other modes in price and convenience, as well as on the value that travellers place on convenience. A survey conducted for the study asked travellers to imagine choosing between an HSR and their current mode of travel. For most travellers along the corridor, the current mode is road or air transport. The survey specified the fares, travel time and frequency of service for the HSR. The specified values differed between respondents. The survey obtained similar information about the traveller's current mode, as well as more general information about the travellers and their trips. By analysing the responses econometrically, Hensher could infer the value that travellers placed on time savings and other convenience factors. For current business air travellers in discount economy class, for example, the value of time averaged \$36 or \$46 per hour, depending on the specification of the econometric model (Hensher 1997, p. 442).

The study by Hensher is an example of stated preference (SP) analysis. An earlier study used SP analysis to evaluate a proposed HSR (the Very Fast Train) along the Sydney–Melbourne corridor (Access Economics 1990).

Stated preference analysis has its drawbacks, despite being a frequently valuable tool. In particular, respondents to a survey can have trouble evaluating unfamiliar alternatives.

For example, some of those surveyed about travel options along the Canberra–Sydney corridor may have had only a hazy idea of the travel time between the HSR station and their origin or destination. The survey did not provide respondents with such information (Hensher 1997, p. 433), as this would have been difficult for so many different origins and destinations. Ignorance on this point could result in some discrepancy between the respondents' statements and the extent to which they would actually use an HSR service, were one available. In addition, some respondents would have been ignorant of the taxi fare to and from the HSR station, should they require a taxi.

Convenience benefits from improved rail freight services

For freight transport, road services are usually more convenient than rail services. They are typically superior in reliability, speed and flexibility of handling. Even major improvements in rail freight services may fail to eliminate these gaps between road and rail. The proposed Brisbane to Melbourne inland railway is a case in point (BTCE 1996b, pp. 34–36). The railway would significantly improve the transit times and reliability of rail services. For rail container traffic from Melbourne to Brisbane, the estimated reduction in transport time was from 33 hours to 25 hours (that is, a reduction of only 8 hours). Even with this improvement, however, the estimated transport time was significantly longer than for road transport (20 hours).¹³

What would draw customers to railways that offer inferior, albeit improved, quality of service? In a word, price. Freight charges are generally lower for rail services than for road. The charges assumed in one Australian study were 4 cents per net tonne-kilometre for rail, and 7 cents for road (BTCE 1996b, pp. 39–40).

An improvement in rail freight services can thus have mixed effects on convenience. Existing customers would enjoy greater convenience. On the other hand, customers switching from road transport, which

¹³ This comparison tends to understate rail's relative slowness, because the rail transit times are only for the line haul between terminals. The time involved in moving freight to and from rail terminals can add significantly to total rail transit time. In addition, while trucks can be dispatched as soon as they are loaded, rail freight has to wait for the next train. This is particularly relevant for parcels and small containers that are normally consolidated into full loads in freight forwarders' terminals. Freight forwarders can usually offer same-day pick up and dispatch for such cargoes sent by road but a next-day dispatch for rail.

is rail's main competitor for freight business, would suffer a loss of convenience (which is more than offset by the reduction in freight charges in moving from road to rail).

BCAs of rail investments have rarely valued convenience effects for freight. Some analyses (BTCE 1988, 1993) have focused instead on the saving in total operating cost (TOC) of land freight services, that is, road and rail combined. Diversion of freight from road to rail contributes to the savings because the operating costs arising from a given shipment are often lower for rail. Reductions in operating costs for existing rail freight traffic can also contribute to the savings, particularly for upgradings of existing railways. However, the saving in TOC is only a partial measure of benefit. Significantly, it fails to reflect changes in the convenience of freight services, which, as discussed above, could be either positive or negative. Hence the TOC measure of benefit could either overestimate or underestimate total benefits.

BTCE (1996b) devised an alternative measure of benefit for its study of the Brisbane–Melbourne inland railway. Unlike the saving in TOC, the alternative measure, termed the 'economic benefit' (EB), takes account of changes in the convenience of freight services. (The BTCE study of the inland railway focused on freight services; potential effects on passenger services were noted but not quantified.) Formally, the benefits from improved convenience enter the EB as the increase in consumer surplus that comes about from a parallel upward shift in the demand curve for rail freight services. The logic is much the same as for consumer surplus measures of benefit from price reductions (chapter 2).

Another advantage of the benefit measure used in the inland railway study is that its bias is better known. Whereas the saving in TOC could overestimate or underestimate the benefit from an improvement in rail freight operations, the EB is likely to overestimate it by exaggerating the convenience benefits. Under reasonable assumptions, the EB defines an upper bound on the amount of total benefit (BTCE 1996b, appendix I). The actual amount of benefit, while not known, must fall short of the upper bound on these assumptions. The strongest assumption is that the demand curves for rail freight services are straight lines. This assumption has precedent in road BCAs, and is reasonable in the absence of information on curvature.

The EB measure of benefit can also be presumed to be more accurate than the TOC measure in certain cases. Because the EB measure is a reasonable upper bound on total benefit, any larger

estimate of benefit is suspect. A special case where the TOC measure turns out larger (and hence suspect) is when rail freight services become cheaper at the same time that their quality improves. In the inland railway study, the BTCE assumed that the investment would reduce rail freight charges, as envisaged by Queensland Rail. The TOC measure of benefit was therefore larger than the alternative measure.¹⁴ Admittedly, the assumption of a decline in rail freight charges was rather arbitrary. In reality, rail investments can lead to higher charges, in which case the TOC measure could be either larger or smaller than the alternative measure.

A reasonable upper-bound measure of benefit, like that devised for the inland railway study, can be useful for preliminary analysis. An investment that appears economically unviable on such a measure is probably not worthwhile for society. Beyond this, upper-bound measures cannot reveal much. An investment that looks economically viable on such measures could be wasteful in reality, since the actual benefit could be much lower than the upper bound. Moreover, measures of the sort devised for the inland railway study, while reasonable, rest on somewhat restrictive assumptions, such as linearity of demand curves.

Intensive research could allow more accurate valuations of freight convenience effects. An SP analysis might serve similar functions for rail freight as it has for high-speed passenger rail. Potentially, it could estimate the value attached to aspects of service quality and, at the same time, the amount of modal diversion.

The International Road Transport Union (IRU), for example, in 1993 conducted an SP analysis for long-distance freight shipments in Europe. The study asked shippers for their preferences between transport options differing in price and several attributes of service quality. The quality attributes were transport time, reliability, flexibility and probability of damage. By analysing the responses, the study estimated the value to shippers of changes in each attribute. It also valued the convenience cost of possible government initiatives, such as taxes, to encourage shipments to move by rail rather than road.

¹⁴ The BTCE analysed four investment options, two for the inland railway and two for the existing coastal railway. For the more expensive of the two coastal options, the estimated BCR was 1.15 using the TOC measure of benefit, and 0.96 using the alternative measure. For the other investment options, the choice of benefit measure had smaller effects on the estimated BCRs (BTCE 1996b, pp. 47–60).

(Some Europeans support such initiatives on environmental or other grounds.)

In Australia, future research could build on a recent SP analysis of road freight choices (Wigan et al. 1998), and on a study of the quality of rail freight service (BTCE 1997b).¹⁵

IN SUMMARY

Research is needed to improve the valuation in transport BCA of certain time-related benefits:

- Convenience benefits from savings in freight travel time, such as increased scope for time-sensitive operations. Allowances for these benefits are patchy and highly conjectural
- Benefits from travel times becoming more predictable are rarely measured, but may be significant. Unpredictable delays can seriously disrupt production and logistic systems.
- Savings in non-business travel time are generally valued in BCAs, although there is much uncertainty about which values are appropriate. Some BCAs have discounted small time savings, but the practice is hard to defend.

Recent studies have used stated preference analysis to estimate values for time-related benefits for freight traffic. This appears to be a promising avenue for research.

In addition to stated and revealed preference analysis, optimisation software used by logistics managers (some of which is commercially available) might help value convenience effects for freight.

¹⁵ Other intensive methods of research, aside from SP analysis, may also help value freight convenience effects. A revealed preference analysis examines the choices that people actually make among the options that face them in reality. It has both advantages and drawbacks compared with SP analysis, which considers stated preferences among options that are partly or wholly imaginary. Revealed preference analysis featured in Hodgkin & Starkie (1978), which examined freight forwarders' choices between sea and road transport. Booz, Allen & Hamilton (1998) conducted both revealed and stated preference analyses to estimate the effects of proposed rail investments. However, the results of these preference analyses were considered too confidential to be reported.

ESTIMATED?

SHOULD EMPLOYMENT CREATION BENEFITS BE

"... and the project will create jobs."

So say many proponents of public investments in transport infrastructure.

But the proponents tend to consider only the positive employment effects. Negative effects can also arise. The question for this chapter is how the project will affect 'aggregate employment': that is, total employment at the national level. When all effects are considered, an overall gain in aggregate employment becomes quite speculative.

Some of the employment effects arise from the input requirements for construction and operation of the infrastructure. Others arise from the transport improvements that the infrastructure produces, such as savings in travel time. The following discussion focuses first on the effects of input requirements. To achieve this focus, one could imagine investments that yield no improvements (pure 'white elephants').

AGGREGATE EMPLOYMENT EFFECTS OF INPUT REQUIREMENTS

The construction and operation of infrastructure requires labour plus other inputs that depend on labour for their production. The total labour requirement for an infrastructure project includes all labour used along the chain of production. For example, the total labour requirement for railway construction includes labour to lay the track, to produce steel for the track, to produce iron for the steel, to mine iron ore, and so forth.

The input requirements can thus increase employment in some workplaces. Some input requirements are met from abroad, however, and so do not create employment within the investing nation. Australia imports much of the machinery used for transport infrastructure projects: the machinery for laying pavements, for example, appears to be almost wholly imported (BTCE 1996c, p. 22).

Furthermore, even within the investing nation, the input requirements of an infrastructure project can reduce employment in some workplaces because of constraints on economic resources and government budgets.

Resource constraints

Availability of labour

The availability of labour is a constraint on the Australian economy. The input requirements for infrastructure affect demand for labour, but demand is only one side of the labour market. Employment outcomes also depend on the availability of additional workers.

The availability of additional workers varies over the business cycle and between segments of the labour market. Even during recessions, it will be limited in some segments. During the early to mid-1980s, the unemployment rate reached unusual heights, but Australia still listed for immigration purposes several occupations as being in short supply (including economists). There are also regional shortages for particular occupations, such as those chronically reported for doctors in many rural areas.

When workers are in generally short supply, a new infrastructure project will not affect aggregate employment by much. Suppose, for example, that the project has a large engineering input and that engineers are in short supply.¹⁶ The increased demand for engineers, more than increasing their total employment, would tend to drive up their cost. Engineers would earn higher wages and other rewards, and the cost of recruiting them would increase (due to competition among recruiters). The higher cost of employing engineers would induce some overall reduction in demand for their services. The drop in demand would, in effect, free up a supply of engineers for the new infrastructure project.¹⁷

¹⁶ Although the example is hypothetical, Yates (1999) reported a shortage of rail engineering skills in Australia.

¹⁷ The higher wages could also attract additional workers into the labour force. For a parent of young children, for example, higher wages could clinch the decision to work part-time. The labour force expansion would lead to an increase in aggregate employment. However, available evidence suggests that the rate of labour-force participation is insensitive to changes in wages.

Moreover, it only takes a scarcity of key workers to limit a project's employment effect. The project may use unskilled labourers who are in plentiful supply. However, if the project cannot expand total employment of engineers, it is likely to displace some other engineering project, which might also have used unskilled workers. Under these circumstances, the employment of unskilled workers may not even increase.

Even when workers are in plentiful supply, collective bargaining can create artificial scarcity. Collective bargaining is prevalent in sectors that are key suppliers for infrastructure projects: non-residential construction, mining and manufacturing. A project that increases demand for labour in these sectors can stiffen union demands for better pay and conditions. When the demands are met, the cost of labour increases, which reduces the demand for workers. The collective bargaining creates, as it were, an artificial scarcity of workers — a constraint on labour supply.

Availability of capital

The availability of resources besides labour will also shape the employment effects of an infrastructure project.

Capital availability is especially relevant to temporary increases in infrastructure spending. Imagine a program with a sunset clause that funds extra spending on infrastructure (like the Federal funding announced in the *One Nation* statement of 1992). Businesses that supply the infrastructure — directly, or indirectly through input linkages — will face increased demand for their output. To cater to this temporary increase in demand, the businesses will rely as much as possible on relatively reversible measures. For example, they might reduce inventories, increase overtime for their workers or take on casual workers. Since the businesses will be reluctant to meet the temporary increase in demand by investing in fixed capital, the existing stocks of fixed capital will constrain their operations.

Capital availability also shapes the effects of more lasting increases in infrastructure spending. The suppliers of inputs to infrastructure start to invest more when demand for their product rises. But the resulting build-up of fixed capital occurs only gradually. There are physical and economic limits on the rate of accumulation. A factory cannot be built overnight. Businesses that attempt to buy equipment in a hurry may have to pay a premium for a rush order. They may also run a greater risk of mistakes — choosing the wrong equipment or supplier. In the short run, an expanding business may have to make

do, to some extent, with its existing stocks of equipment and structures.

Constraints on capital stocks explain key findings in BTCE (1996b) about the employment effects of road construction. The findings pertained to the short-run effects during the construction phase and derived from the ORANI model of the Australian economy (box 5.1). Simulations with the model indicated that additional spending on road construction would cause a real appreciation of the Australian dollar. In other words, it would make Australian goods more expensive relative to competing foreign goods. For this reason, the simulations also indicated that the additional road spending would reduce output and employment in some industries that face strong overseas competition. (For related discussion of the employment effects of changes in aggregate demand, see Malakellis & Peter 1991.)

The appreciation of the real exchange rate has the following intuitive explanation. Assume that inputs for the additional infrastructure would consist mainly of Australian-made products (a reasonable assumption for many projects, despite much machinery being imported). Now, an increase in demand for a product will generally raise its price, and the same is true for the economy as a whole. An increase in the total demand for Australian output will raise the overall level of domestic prices relative to foreign prices.

A more formal explanation of the appreciation of the real exchange will clarify the connection to capital stocks. The prices of Australian products reflect the costs of their production. When the total demand for Australian output increases, the existing stocks of fixed capital in Australia become more valuable, which pushes up their prices. The resulting increase in the cost of Australian capital shows up in higher prices for Australian products relative to foreign prices.

Government budget constraints

Governments often bear the financial costs of transport infrastructure projects. How do they meet these costs?

Reduce other public expenditure

Governments can meet the cost of an additional transport project by spending less on something else. The current environment of public belt-tightening makes such a response highly plausible.

BOX 5.1 EMPLOYMENT EFFECTS OF ROAD CONSTRUCTION

Suppose the public sector had spent an additional \$630 million on road construction in 1994–95. How would the expenditure have altered the Australian economy in that year?

The BTCE (1996c) tackled this question using the ORANI model of the Australian economy. The assumed increase in road construction spending was \$630 million, similar to that under the Federal One Nation statement of 1992. The increased spending was also assumed to be temporary, again like the One Nation funding. It would have added about 11 per cent to government road spending in 1994–95.

The BTCE focused on the contemporaneous effects of the expenditure: the effects after construction, during the operation of the roads, were not modelled. (An implicit assumption was that construction of the roads would take at least a year.)

ORANI requires users to input their own assumptions about wage determination. The BTCE assumed, for illustration, that the increase in road construction expenditure would have no effect on real wage rates (or on other components of real employee compensation). The assumed absence of real wage effects is common to many ORANI analyses of short-run scenarios.

To incorporate capital constraints, the BTCE assumed that the additional spending would have no effect on stocks of fixed capital outside the road construction industry. The assumption made for the road construction was that the stock of fixed capital would change in line with output. The modelled increase in the industry's output (11 per cent) was too large to be realistically met without an increase in the stocks of equipment and machinery (such as pavement layers).

The BTCE found that the additional spending on road construction would cause a real appreciation of the Australian dollar, pushing the trade balance toward deficit. Negative output and employment effects were indicated for some industry sectors that are export-oriented (agriculture and food processing) or strongly import-competing (textiles, clothing and footwear, for example).

Despite the losses in trade-exposed sectors, the increase in roadconstruction spending would increase employment overall, according to the ORANI results. The estimated overall gain was 17 jobs per million dollars of expenditure. The absence of labour supply constraints and other simplifications in the modelling would have biased this estimate upwards; the BTCE called for 'extreme care' in its use.

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Suppose that a government forgoes expenditure on goods and services (rather than transfer payments like unemployment benefits). Production of the forgone goods and services would have generated demand for labour, possibly more than the transport project. To take an Australian example, spending on 'welfare services' — garbage collection, police protection and the like — generates more demand for Australian labour than does the same amount of spending on road construction, according to BTCE (1996c, p. 32). Such services appear to be more labour-intensive than road construction, and less dependent on imports.

Increase taxes

Governments can also fund infrastructure projects by increasing taxes. The effects of taxes on aggregate employment are highly complex.

Take the simplest case of a special poll tax. The tax collects the same amount from each of society's adults, regardless of individual circumstances. Payment of the tax reduces disposable incomes, which could affect aggregate employment by:

reducing consumer spending. A fall in consumer demand should reduce aggregate employment, according to conventional thinking. Strange as it may sound, though, the opposite outcome is also possible. A fall in consumer demand could increase aggregate employment in the short run, according to results from the ORANI model of the Australian economy. The possibility arises from the large place that housing occupies in consumer budgets, combined with the lags with which housing stocks respond to changes in demand (for more explanation, see BTCE 1996c, pp. 31–32).

reducing the level of saving. A fall in disposable income forces people to consume less or to save less. A reduction in saving would result in less investment, with attendant losses in employment creation. The international mobility of capital attenuates the link between domestic saving and domestic investment, but does not remove it. (See chapter 9's discussion of the current account balance.)

increasing labour supply. People would want to work more to make up for the loss of disposable income caused by the tax. Employment, in this respect, would tend to increase.

Actual taxes in Australia affect aggregate employment through additional channels. Unlike the hypothetical poll tax, they impose burdens that vary with people's circumstances. In particular, people on higher incomes tend to pay more, directly or indirectly, for most

taxes (personal and corporate income, sales and excise, and so on.) In this respect, taxes weaken the incentive to produce additional income. The loss of incentive reduces aggregate employment by discouraging labour supply. It also inhibits national saving, which, by limiting the funds available for investment, can further diminish employment. Taxes on Australian-sourced income can deter investment in Australia in another way too — by causing some foreign investors to look elsewhere.

The US experience of tax reform provides some insights into how personal income taxes can affect labour supply. Reforms introduced in the 1980s reduced marginal income tax rates, particularly for the rich: the top Federal income tax rate fell from 70 per cent in 1980 to 28 per cent in 1988. Most economists agree that the reforms caused a 'small, but real increase in labour supply', although estimating the effect is 'extremely tricky' (*The Economist*, 24 August 1996, p. 64). The increase in labour supply occurred largely among women, 'with the biggest effect coming from those on relatively high incomes'.

In short, tax funding for public expenditures *may* reduce aggregate employment, which calls into question the employment-creation potential of public infrastructure projects.

Government borrowing

Governments can also borrow to finance infrastructure investment. Economists have argued endlessly about differences between the real effects of taxes and public borrowing. A 19th century pioneer of economics, David Ricardo, floated and rejected an argument which implies little difference, and which Robert Barro revived and embraced in 1974. (See Dornbush & Fischer, pp. 289–291.)

The simple version of Ricardian equivalence is that additional public borrowing leads eventually to higher taxes. The assumption is that the government will have to raise taxes to pay off the principal and interest on the debt. Straightaway, however, people start to curb their consumption in anticipation of the eventual tax increase. In so doing, they stabilise their consumption over time. The immediate restraint in consumption adds to saving, and the returns to the additional saving cushion the future loss of disposable income, when taxes are raised. Under Ricardian equivalence, public borrowing results in the same time path of consumption as would an upfront increase in taxes.

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A detailed discussion of Ricardian equivalence and the surrounding controversy is beyond the scope of this report. Suffice it to say that an increase in government borrowing can affect the economy in somewhat similar ways to an increase in taxes. So if tax financing of an infrastructure project would reduce aggregate employment, so might government borrowing. (For more on the economic effects of government borrowing, see *The Economist* 24 November 1990, pp. 73–74 and 10 February 1996, pp. 78–79.)

Crowding out of other investment

The allocation of resources to an infrastructure investment is likely to displace, or 'crowd out', other investment. It leaves fewer resources for other production, which forces some cutbacks in expenditures on goods and services. The cutbacks will generally include investment along with consumption.

The amount of crowding out of other investment is partly definitional. In the national accounts, 'investment' is the accumulation of physical capital (inventories, equipment and structures). Economists tend to use this definition unless they indicate otherwise. However, much consumption expenditure has investment characteristics. For example, the salaries of government schoolteachers represent an investment in our children's future, although they enter the national accounts as public consumption. Economists describe such expenditure as investment in 'human capital'. (For more on the narrowness of the national accounts definition of investment, see *The Economist*, 11 July 1998, p. 82.)

Crowding out of other investment adds to doubts about employment creation from infrastructure investments. A displaced investment could have given a sustained boost to employment: a factory can provide employment long after its construction. Likewise for consumption expenditure with investment characteristics. Education not only employs teachers, it also makes students more employable later on.

AGGREGATE EMPLOYMENT EFFECTS OF BETTER TRANSPORT

Transport projects may affect aggregate employment through their input requirements, as discussed above, and also by improving the transport system.

Improvements to the transport system can have mixed effects. On the negative side, they often reduce the labour requirement for a

given transport task by saving travel time. Better roads, for example, can reduce the number of driver hours needed for deliveries.

On the positive side, improvements to the transport system reduce the costs of production and increase profits. The cost reductions induce businesses to increase their supply of output, while the higher profits attract additional investment. In both these ways, the demand for labour increases.

In addition to altering demand for labour, transport improvements can affect labour supply. Improvements to commuter transport probably have the greatest influence.

One might think that better commuter transport would necessarily increase labour supply. It would increase the number of people who want to work and, for people already employed, a shorter commute would leave them more time for work.

But savings in commuting expenses (such as costs of petrol) leave workers with more money. Hence some workers may feel less need to work long hours to attain the material standard they aspire to. (This is the well-known 'income effect' in economic theory.)

POSSIBILITIES FOR ESTIMATION

The effect of an infrastructure project on aggregate employment is extremely difficult to estimate.

For one thing, the employment outcome depends on how the project affects wage levels, and the process of wage determination is hard to model. Some have attempted to model wage determination in Australia through econometric analysis of past experience. How well they have explained what drove wages in the past is an open question; econometric analyses have failed to produce reliable findings on some other issues, despite massive efforts. For example, the macroeconometric literature on infrastructure payoffs has yielded no firm conclusions (chapter 12). More fundamentally, past patterns of wage determination may be a poor guide to the future, especially with major reforms to the Australian labour market now being implemented (Hancock 1998; Richardson & Hancock 1998).

The unpredictability of the business cycle also hinders estimation. Infrastructure projects have greater employment-creation potential when undertaken during periods of high unemployment. Infrastructure projects can also take several years to plan and implement. So to estimate the employment effects of a project can require long-term

forecasts of the unemployment rate — something that economists have had limited success with.

Input-output analysis

The misuse of input-output (IO) analysis makes the estimation of aggregate employment effects look deceptively easy.

An IO analysis can provide an estimate of the total employment requirement of an infrastructure investment. This is quite different from estimating the effect on aggregate employment. As explained above, labour required for an infrastructure investment will displace employment elsewhere in the economy. The displacement arises from constraints on government budgets and economic resources. Input-output analysis ignores these constraints, and so cannot validly estimate the effect on aggregate employment.

An IO analysis can relate to a national or regional economy, and the ignored constraints generally matter more at a national level (the perspective in this chapter). In particular, constraints on labour supply are typically weaker for regions than for the nation. An infrastructure project can draw labour toward certain regions within a nation — to where construction is taking place, for example. Since labour is regionally mobile to some extent, the supply to any one region responds to changes in demand. Labour is less mobile across nations because of immigration hurdles plus barriers of distance, language and culture.

Many discussions of infrastructure investments draw on IO estimates of employment requirements. All too often, they gloss over or fail to mention the displacement effects, as, for instance, do some analyses of public transit projects (as noted by Beimborn & Horowitz 1993, pp. 25–26). Language such as the number of jobs 'created' invites misinterpretation of the estimates as net gains in aggregate employment. To their credit, some discussions acknowledge the omission of displacement effects (for example, Keane 1996, p. 35).

Further potential for obfuscation exists in induced-consumption 'multipliers'. Some IO analyses of infrastructure projects add to the project's employment requirement an additional employment gain derived from these multipliers. The assumed scenario runs so: an infrastructure project uses workers, all of whom would be jobless in the project's absence; by increasing aggregate employment, the project also increases total labour income; workers devote part of their additional income to consumption; the increased production of consumer goods provides jobs for still more workers, who, in

turn, increase their consumption; and so on. In some IO analyses, induced consumption generates much more employment than the project does directly through its labour requirement (BTCE 1996c, p. 33). For small enough regions, such outcomes are conceivable. At a national level, however, the input requirements of infrastructure projects can be expected to *reduce* consumption spending (box 5.2), notwithstanding the increases indicated by some IO analyses (for example, Starkie & Mules 1983).

BOX 5.2 HOW THE INPUT REQUIREMENTS OF INFRASTRUCTURE INVESTMENT AFFECT CONSUMPTION SPENDING

In general, the input requirements of an infrastructure project will reduce consumption spending at the national level.

For concreteness, consider the labour requirements of a project that is tax-financed.

The project provides income for the workers it employs, including indirectly in the industries that supply inputs. But the income comes from the taxpayers' pockets. So it represents a redistribution of disposable income rather than a net increase. If only for this reason, one would expect little effect on aggregate consumption expenditure (a point conceded by Boltho & Glyn 1995, p. 465, despite their call for tax-financed spending to create employment).

In addition, the use of workers for the project will reduce employment elsewhere in the economy (as explained earlier in this chapter). Such loss of employment will in turn reduce disposable income and hence consumption spending.

National economic models

National economic models add relationships that are absent from IO frameworks, such as constraints on resources and government budgets. But the realism of the added relationships is open to question, particularly when it comes to labour markets. The wage determination process is only one of the challenges for modelling labour markets. Much remains to be understood about labour supply and demand, including the dynamics of adjustment. Concerns about realism are hardly allayed by the mystery that surrounds many national economic models. All too often, full and transparent documentation is unavailable.

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The literature on 'internal' labour markets (within an enterprise) illustrates the gaps in knowledge. The contributions to this literature incorporate features of labour markets that many other models ignore. In particular, they focus on the acquisition by workers of skills that are specific to their workplace, and the difficulties in obtaining information (for example, about the performance and abilities of workers). However, Baker & Holmstrom (1995), drawing on the US experience, noted that the empirical underpinning of these models was weak. From two case studies of company personnel records, they found much more flexibility in compensation practices than most existing models of internal labour markets allowed for. Their call for more case studies might well be heeded in Australia, where recent shifts toward individual and enterprise bargaining has heightened the relevance of enterprise-level arrangements. (For a survey of labour market models from an Australian perspective, see IC 1993, chapter 5.)

Various studies have used national economic models to estimate the employment effects of transport infrastructure projects.

BTCE (1996c) used the ORANI model to estimate the employment effects of road construction activity, but the omission of labour supply constraints introduced upward bias (box 5.1). Some other studies have also acknowledged this bias in their estimates of the employment effects of road investments during or after construction (Allen Consulting et al. 1996 p. 30; Allen Consulting 1993, p. 74).

The other studies that have come to the BTE's attention inspire little confidence because they explain their findings sketchily, use models that lack transparency, or make arbitrary assumptions. Chapter 9 of this report examines one study, which estimated employment gains from an upgrade to the Princes Highway in Victoria (Brain 1997).

A study edited by Roy (1996) analysed the PBKAL, a high-speed rail link between five cities in Europe (Paris, Brussels, Cologne, Amsterdam and London). A novel feature was the estimation of employment effects from savings in leisure travel time. The study assumed that such savings would increase labour supply: that the leisure travellers on the PBKAL would want to apply part of their time savings to work. The study also predicted that the increase in labour supply would depress wage levels and thereby increase demand for labour. Although the scenario is plausible, the estimate of the increase in labour supply depends heavily on an assumption



that the study does not fully justify.¹⁸ In some other respects too, the study provides limited information for an assessment.

Another study (CEBR 1994) used a model of the British economy to estimate the employment effects of road investments. The BTE requested documentation of the model but was informed that it was unavailable to the public (for commercial reasons).

The impression that is gained of national economic models is that they are unlikely to produce credible estimates of the aggregate employment effects of transport projects.

Valuation of employment creation benefits

If aggregate employment effects are not amenable to estimation, how to value them is a largely academic question that warrants only brief discussion in this chapter.

People are so used to thinking of a gain in aggregate employment as a benefit that they easily forget the costs. Mention costs, and they usually think of financial costs like wages and payroll tax. The financial costs are not costs to society in themselves — they are merely exchanges of money between different segments of society.

The opportunity cost of workers' time is the main cost to society of employment. The additional workers must forgo some other use of their time in order to spend time working. The forgone activity would also have achieved something positive, save for exceptions like crimes. The activity could have been studying, job search, relaxing, working around the house, whatever. The social cost of an increase in aggregate employment also includes work-related expenses such as costs of commuting and childcare. To ignore the social costs of additional employment is to overestimate the benefits from employment creation.¹⁹

¹⁸ The study used a model of the European economy in which savings in commuting time increase labour supply. Because leisure travel time was absent from the model, the study adopted an auxiliary assumption. It assumed that a saving in leisure travel time among workers increases labour supply by 25 per cent as much as the same saving in commuting time. The rationale was that leisure travellers typically value time savings about 25 per cent as much as do commuters, according to the study's reading of European evidence (ed. Roy 1996, p. 10). But the logic underlying this rationale is unclear.

¹⁹ Granted, the costs of the additional employment (should it actually eventuate) would presumably be less than the benefits. Most people believe aggregate employment is below the socially optimal level.

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The costs of additional employment are hard to value, as various discussions have shown (for example, DoF 1991, and Richardson & Travers n.d.). Some transport BCAs forgo the effort (perhaps rightly), and yet value the benefits of additional employment. This practice biases key measures of investment performance, such as the benefit-cost ratio, in the investment's favour. People should realise when this has been done, but some analyses adopt the practice without acknowledgment.

Analyses with this lopsided valuation are mainly of two types.

Some analyses are based on simulations with national economic models. In the simulations, a transport investment produces a net benefit — as measured by the gain in real consumption or real GDP — partly because it increases aggregate employment. The measures of net benefit do not, however, reflect the cost of the additional employment (see chapter 9 for further discussion).²⁰

Other analyses resort to an extreme form of shadow pricing, which marks down to zero the costs of additional workers. BCAs of European port investments, for example, have sometimes adopted this practice (as found by DeBrucker et al. 1995, pp. 4–7). They assume that the port project draws a certain fraction of its workers from other production activities. The costs of employing these diverted workers are measured by financial costs. The other workers, who are assumed to come from the ranks of the unemployed, are additional to the economy's existing workforce. The cost of employing the additional workers is assumed to be zero. To illustrate, suppose that the total financial cost of the project's workforce is \$400 million, and that 20 per cent of the workers are assumed to be additional. The practice just described would measure the total labour cost as only \$320 million (= 80% x \$400 million). Such was the calculation in a BCA of options for the Tasmanian railway system (BTCE 1991, p. 65).

²⁰ In concept, the measures could reflect some opportunity costs of employment — for example, if someone forgoes studies to take up employment, their future productivity may be lower, which would show up in national output (real GDP). In practice, studies of transport investments that have used national economic models do not appear to have captured such effects.

IN SUMMARY

Reliable estimates of the aggregate employment effects of transport investments are unavailable. Transport BCAs should exclude such effects from their estimates of net benefit; the working assumption should be that such effects are absent, as various government agencies have recommended in their BCA guidelines (OMB 1992, p. 7; DoF 1991, pp. 34–35.)

The notion that some estimate is better than no estimate is dangerous. An estimate must be sufficiently reliable to justify the time and effort for its derivation. Moreover, people often present unreliable estimates dishonestly, without reporting essential qualifications and explanation.

BCAs of transport projects can usefully discuss aggregate employment effects without actually estimating them. At the very least, they can discourage simplistic thinking on the subject. People should realise that transport investments can either increase or decrease aggregate employment, depending on the investment and circumstances. Perhaps in some cases, an examination of the particulars will justify a hunch about the direction of the effect and whether it will be significant. A BCA that reports the hunch should supply reasoning and evidence, and indicate its speculative nature.



6

ARE DISCOUNT RATES TOO HIGH?

Discounting future benefits and costs is almost universal in BCA. Benefits and costs that lie further into the future receive smaller weight than those which are more imminent. (box 6.1). Discounting reduces the benefit-cost ratio for most projects because costs normally precede benefits. The choice of discount rate determines the magnitude of the reduction.

The justification for discounting does not usually involve inflation. Indeed, most BCAs use real measures of benefits and costs, which exclude the effects of inflation. Yet they still discount.

The most popular justification for discounting is that, to be worthwhile, public investments should at least match the rate of return on private investments (Lind 1997, p. 54; GAO 1991, p. 28).²¹ Basing the discount rate on some measure of private rate of return is an attempt to impose this requirement.

A practical hitch with this basis for discount rates is that private investments vary in their rate of return. In particular, riskier investments tend to average higher rates of return than safer ones.

For example, a project with a net benefit stream (-1, 5, -6) has two changes of sign and two rates of return, at 100 per cent and 200 per cent (example from Hirshleifer 1970, p. 77). For such projects, rate of return comparisons cannot guide investment decisions. The project may have some rates of return above the private sector benchmark and others below. Even when all rates of return exceed the benchmark, the project is not necessarily worthwhile. (Hirshleifer discusses these points.)

²¹ For public investments with the normal pattern of costs preceding benefits, the justification makes sense. However, some projects have more complicated patterns. A nuclear power plant has construction costs at the start, decommissioning costs at the end, and benefits in between. It would thus have two reversals of sign in its stream of net benefits: from negative to positive, and back to negative. For projects with more than one reversal of sign, there can be multiple rates of return — as many as there are changes of sign.

BOX 6.1 THE ARITHMETIC OF DISCOUNTING

A stream of net benefits over time has a present discounted value (PDV). The formula is:

$$PDV = b_0 + b_1 \times R_1 + b_2 \times R_2 + b_3 \times R_3 + \dots + b_T \times R_T = b_0 + \prod_{t=1}^{T} (b_t \times R_t)$$

where:

the time periods (usually years) run from O (the present) to T;

 b_t is the net benefit during period t; and

 R_t is the present value of a dollar of net benefit arising in period t

Most BCAs simplify the above equation by assuming a constant discount rate. The assumption is that:

 $R_t = 1/(1 +)^t$

where is the discount rate. After this simplification, the equation for the PDV becomes:

$$PDV = b_0 + \frac{b_1}{(1+)} + \frac{b_2}{(1+)^2} + \frac{b_3}{(1+)^3} \cdots + \frac{b_r}{(1+)^T} = b_0 + \frac{b_1}{t=1} \frac{b_t}{(1+)^t}$$

To illustrate, imagine a project with the following stream of net benefits (in, say, M): -1000, 200, 300, 700.

At a discount rate of 10 per cent, the PDV equals:

$$-1000 + \frac{200}{(1.1)} + \frac{300}{(1.1)^2} + \frac{700}{(1.1)^3} = 44$$

The PDV of a stream of net benefits is also called the 'net present value' (NPV). It varies inversely with the discount rate, except in special cases. In the present example, the NPV would rise to 67 at a discount rate of 5 per cent, but would be negative at a discount rate of 15 per cent (NPV= -139).

This is because many people are unwilling to assume extra risk without some expectation of higher returns. Thus the problem is to select a private rate of return among the many to be found.

A popular 'solution' to this problem is to find private projects with a similar risk profile to the project being evaluated. The discount rate, under this approach, equals the average rate of return on the counterpart private projects.

However, the identification of counterpart projects is often tricky. In addition, the whole idea of factoring risk into the discount rate has met with serious reservations from many economists (below). As this chapter shows, the result can be significant distortions to decision-making, which more rigorous treatments of risk can avoid — at least in principle.

Largely because of the issue of risk, economists disagree a lot about discount rates.

One camp favours a discount rate equal to the rate of return on some ultra-safe asset. Ideally, financial markets would contain some perfectly safe haven, an asset with a totally predictable rate of return. Since this 'riskless' asset does not exist, economists turn to a very safe asset, such as a government bond with a high credit rating.²² Some US government agencies have adopted such a discount rate policy for evaluating public investments and regulations (GAO 1991, pp. 6–7).

In Australia, such a policy would lead to the interest rate on 10 year Commonwealth bonds (CBR-10). Ten years is the longest term on Commonwealth bonds; and a long-term rate accords with transport projects, which mostly generate benefits for decades. Nominally, the CBR-10 averaged between 5 and 6 per cent per annum during the six months to March 1999 —.say 5.5 per cent for calculations (At the time of printing in November 1999, the CBR-10 was about 6.5 per cent.) In comparison, the expected rate of Australian inflation was only about 1.5 per cent.²³ The expected real CBR-10 was thus around 4 per cent (= 5.5 - 1.5) in the middle of 1999.

But many Australian BCAs have used much higher discount rates to allow for risk. Many have used a rate of about 8 per cent, following the advice of DoF (1991, p. 58). Several 1990s' evaluations of rail

Even without downplaying risk, however, many economists have demurred at risk-adjusted discount rates (for example, Corti 1973).

²² Within this camp, some have downplayed the relevance of risk to BCAs of government investments. One argument is that many people share in the benefits and costs, making the risk to each person negligible. Another is that government investments are highly diversified, so that good and bad fortune average out to a large degree. Arrow & Lind (1970) drew on both arguments in their seminal paper. For a less technical exposition and cogent counter-arguments, see Pearce and Nash (1981, pp. 74–77).

²³ This is measured as the difference between CBR-10 and the 2010 CPI indexed bond rate. The figures for these rates are taken from Abelson (1999, pp. 13–14).

projects used even higher rates. The preferred rate was 11 per cent, for example, in an evaluation of a proposed inland railway from Brisbane to Melbourne.²⁴

The effect of discounting can be severe at such rates. The inland railway might generate benefits for 30 years, as was assumed in the evaluation. One hundred dollars 30 years from now has a present value of only about \$4, at the evaluation's discount rate of 11 per cent. (In other words, to reap \$100 in 30 years from now, a BCA could only approve a current sacrifice of \$4.) However, at the Commonwealth bond rate of 4 per cent real in the middle of 1999, the same future sum would have had a present value of \$31.

Discount rates far above the government bond rate have thus drawn protests from some quarters. A report prepared for a water development board argued, for example:

If the benefits of projects are required to be discounted at a real [inflation-free] rate of 10% then only those with quick payoffs will be considered and long sustained benefits will count for little. In view of the fact that shortsightedness by planners is universally condemned, it appears that the high discount rate policy is inconsistent with community expectations (Taplin 1993, p. i).

In addition to risk, the literature on discount rates emphasises the form of benefits and costs. A nation can secure the resources for an investment by sacrificing other investment. Alternatively, it can consume less or borrow from abroad. The costs of the investment to the nation can take any of these forms. Likewise, the benefits to the nation can take alternative forms. A gain in national output could be devoted to investment or consumption, or to reducing foreign debt. A project can also cause changes in consumption outside the market economy. A saving in commuting time, for example, may result in more time relaxing at home, which is akin to consuming more.

When benefits and costs are mainly in the form of consumption, the relevant discount rate is the 'social time preference rate' (STPR), a concept that is explored below. Economists are divided about an appropriate value of the STPR and its role in discounting, as they are about the treatment of risk. Different stands on these issues can lead to widely varying discount rates.

The main proponent of the inland railway, Queensland Rail, discounted at 11 per cent in its own investment appraisals (BTCE 1996b, p. 45).

Sadly, many BCAs offer little or no justification for their choice of discount rate. They often lean heavily on precedents, the origins of which are sometimes obscure. A discount rate of 7percent has been widely used for Australian transport projects since 1968 or earlier (CBR 1973, p. 42).

Clearly, a fresh look into discount rates for Australian transport projects is needed. The analysis in this chapter identifies a broad direction for improvement, and recommends one specific change that could have significant consequences.

THE MACROECONOMIC COMPOSITION OF BENEFITS AND COSTS

An important issue in BCA is the choice of 'numeraire'. The issue has drawn much attention in theoretical discussions, but less in practice. Most BCAs fail to specify their numeraire.

A numeraire sets the unit of measurement for benefits and costs. Some BCAs merely indicate that the units are in Australian dollars (or some other currency), measured at prices in some base year. But a numeraire, as the term is used here, also indicates what the dollars would acquire, be it consumer goods or something else.

Some BCAs have specified a consumption 'numeraire', estimating an NPV in dollars of consumption. An NPV of \$1 billion then means that the net benefits are equivalent to consuming \$1 billion more at present (a one-time increase).

Alternatively, the numeraire could be some measure of investment. As a thought experiment, imagine a manna-from-heaven increase in investment occurring in the 'present' (whenever that happens to be in the BCA). In other words, additional capital — consisting of factories, computers and the like - suddenly and miraculously materialises. One could also imagine the opposite scenario: capital suddenly vanishes. Some dollar amount of such change (accumulation or evaporation) could describe the welfare effect of any particular transport project. A change of this amount would have the same effect on societal welfare as the stream of net benefits from the project. This amount is what the NPV measures when investment is the numeraire.

The numeraire has attracted attention in theoretical literature mainly because of concerns about taxes and intergenerational fairness. A particular concern is that taxes reduce the incentives to save, so that people may be consuming too much of their income. For a nation, less saving means less investment or more foreign debt. Much of

theoretical literature pertains to economies that have no links with other countries, and hence no foreign debt. In such 'closed' economies, less saving simply means less investment.

Thus a possibility emphasised in the literature is that society benefits more from a dollar of investment than from a dollar of consumption. For example, a dollar of investment might be the welfare equivalent of, say, \$1.15 of consumption. Failure to specify the numeraire would, in such circumstances, cloud the interpretation of the NPV. An NPV of some dollar amount would signify a larger benefit when investment, rather than consumption, is the numeraire.

The appropriate discount rate depends, according to theory, on the choice of numeraire (Bruce 1976, pp. 39–42; or Little & Mirrlees 1974, p. 72). If consumption is the numeraire, a discount rate of, say, 8 per cent, means that consuming a dollar more today gives the same benefit as consuming \$1.08 a year from now. A numeraire other than consumption might call for a different discount rate.

As a rule, the choice of numeraire is somewhat arbitrary. The benefits and costs of a project will take some combination of the forms discussed above: changes in consumption, investment and foreign debt. Any of these forms could serve as a numeraire. For example, with consumption as the numeraire, one would measure the consumption equivalents of changes in investment and foreign debt (the equivalent in welfare terms).²⁵ Such a measurement exercise is known as 'shadow pricing'.

One can further specify the numeraire as relating to private or public expenditure. For example, the numeraire could be private consumption. Merely to specify consumption may not suffice, because the benefit from an extra dollar of consumption may differ between private and public spending.

```
C^* = C + 1.2 x I
= C + 1.2 x 0.5 x C (since I / C = 0.5)
= C x 1.6
```



²⁵ Suppose, for illustration, that the gain in consumption expenditure, C accounts for two-thirds of the benefits in some year, the remainder being a gain in investment expenditure, I. Suppose as well that a dollar of investment is the welfare-equivalent of \$1.20 of consumption. The total benefit in consumption equivalents is C*:

NUMERAIRE AND DISCOUNT RATE: THE RISKLESS CASE

The numeraire and its bearing on the discount rate is already a complex topic, even before considering risk.

To begin, imagine a riskless world. In this case the outcomes of investment projects, and everything else in the global economy, would be known with certainty in advance. In such a world, capital markets would be simpler than they are in reality. The myriad ways of raising capital in the real world — the various forms of debt and equity — represent alternative allocations of risk. A company that finances an investment through equity rather than debt shifts some risk to the suppliers of finance. Naturally, the reduction in the company's exposure comes at a price. An equity issue must offer higher expected returns in order to induce the suppliers of finance to bear the extra risk.

In a world of certainty, such diversity of financial instruments would lack purpose and meaning. The capital market would simply be a market for loans. A single interest rate would prevail at any one time, abstracting as well from limits on competition (such as might arise from government financial regulations).

Foreign debt as the numeraire

From an international perspective, changes in foreign debt represent neither benefits nor costs of a project, but merely transfers of wealth within a global society. If, on the other hand, 'society' stops at the border, changes in foreign debt are a form that the benefits and costs can take.²⁶

When foreign debt is the numeraire, discounting converts future changes in foreign debt to present equivalents. The appropriate discount rate is the real interest rate paid to foreigners, net of withholding tax.

26 The impacts on foreign debt, on their own, would not measure the effect of a project on national welfare (see Chapter 9 on the current account deficit). One would also have to consider the project's impacts on consumption and investment. However, in theory, these other impacts are measurable in foreign debt-equivalents.

The withholding tax is collected by the borrowing nation. For example, the Australian Government collects a 10-per-cent withholding tax on interest paid abroad from Australian sources (CCH Australia 1999, p. 1116). Although there are some exemptions, the tax generally applies to interest on Commonwealth bonds.

For illustration, return to the calculation for 10-year Commonwealth bonds. In the half-year to 1999, the nominal interest rate had been about 5.5 per cent. Net of withholding tax, foreign bondholders would thus have earned 5 per cent (= $5.5 - (10\% \times 5.5)$). With inflation in Australia then expected to run at about 1.5 per cent, the expected net interest rate was about 3.5 per cent in real terms.²⁷ Abstracting from risk, this would have been an appropriate discount rate, were foreign debt the numeraire (box 6.2).

Private investment as the numeraire

When private investment is the numeraire, the discount rate should be the rate of return on private investment. For example, at a 4 per cent rate of return, \$100 of private capital can grow to \$104 a year later. So an additional \$104 of private capital a year from now has a present value of \$100.

BOX 6.2 DISCOUNTING WHEN FOREIGN DEBT IS THE NUMERAIRE

Imagine a transport project with a two-year horizon: construction this year at a cost of \$1,000 million; benefits next year; and no effects thereafter.

The construction costs are funded by foreign borrowing. The foreign debt thereby created grows to 1.035 million next year, at a net interest rate of 3.5 per cent.

The benefits next year go toward reducing foreign debt. For the project to be worthwhile, the benefits must exceed \$1.035 million. Only then will the project more than pay off the foreign debt it creates. In BCA terms, this means that the NPV must be positive at a discount rate of 3.5 per cent.

²⁷ Commonwealth bonds are denominated in Australian dollars, as are benefits and costs in an Australian BCA. Hence the relevant inflation rate is also Australian, and the exchange rate does not matter.
The relevant concept is a marginal rate of return on small changes in private investment. The projects analysed in BCAs are small relative to total investment in the economy. Even if all benefits and costs of a project were to take the form of private investment, the impact on total private investment would be proportionally minuscule.

In addition to being marginal, the rate of return used for discounting should be social. One should measure the benefits and costs of private investment for society. However, social rates of return are hard to measure. So analysts turn to the private rates of return earned by investors, gross of personal income tax. (Tax revenues represent transfers of income within society rather than costs to society.)

Now, in a world of certainty, private investors would earn a marginal rate of return about equal to the interest rate. In other words, the investors would just about break even on a slight increment or decrement to their chosen level of investment (box 6.3).

Thus the interest rate would be the appropriate discount rate if, in addition to risk being absent, the private rate of return were also the social rate.

Private and social rates differ in reality, but it is hard to determine the direction and size of the difference. Company taxes raise the social rate above the private rate; however, the effective rate of company tax is fairly low in Australia (see below). Other sources of difference are harder to quantify. In addition to environmental externalities, they include the effects of imperfect competition (chapter 8).

Company income taxes

Company income taxes depend inversely on the ratio of debt to equity because interest payments are tax-deductible. The deduction of interest encourages financing through debt rather than equity. (Personal income taxes can also discriminate between debt and equity, but ignore this for the moment.) The distinction between debt and equity should, of course, be absent from the imaginary riskless world being analysed. But it is essential for exploring the implications of real-world taxes.

Now consider a marginal investment that is equity-financed. The private rate of return (after company tax) will approximately equal the interest rate. But the payments of company tax, while burdening the company, are likely to benefit society. They could, for example, fund some expenditure on public services.

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BOX 6.3 THE INTEREST RATE AS THE MARGINAL RATE OF RETURN ON PRIVATE INVESTMENT

Consider a company that is deciding how much to invest in computers. The level of investment, measured in units of computing power, is infinitely divisible: the company can acquire any number of units, down to any number of decimal places.

The company's level of computing power obeys the law of diminishing returns. As the level increases, the returns to an additional unit — the *marginal* returns — -diminish. The diminution occurs continuously as in the figure below, rather than at critical points.



The company's optimal level of investment is at C*, where the rate of return on extra units — the marginal rate of return — virtually equals the rate of interest, r. (Were the marginal rate of return defined using calculus, the equality would be exact, as shown in the figure.) A slight increment to C* would be a marginally unprofitable investment, on which the rate of return would be slightly lower than the interest rate. Similarly, the increase to C* from a slightly lower level of investment, C**, is a marginally profitable investment (which is why the company chooses C*). Thus, for very small changes in the level of investment, the rate of return is close to the interest rate. Company taxes thus raise the social rate of return above the interest rate. But under the Australian tax system, the difference is small. Some countries tax company profits twice: first under company income tax and then under personal income tax, when the profits flow to shareholders. Australia has sharply limited the degree of double taxation through its system of tax imputation, whereby payments of company tax earn personal income tax credits for shareholders. So the effective rate of company tax is now low: allowing for it would add only about 0.5 per cent to the real interest rate of 4.0 per cent on Commonwealth bonds. ²⁸

Personal income taxes also would require some adjustment to the interest rate, to the degree that they, like company taxes, discriminate between debt and equity. The BTE has not attempted the necessary calculation, but suspects that the adjustment would be small in Australia's case.

Public investment as the numeraire

Although private investment is the favourite numeraire, public investment is another possible choice (Perkins 1994, pp. 306–308). A BCA may concern a public project that will displace more public

28 The adjusted discount rate is an average real rate of return before tax. Measurement before tax allows for the benefits from the company tax revenue.

The break-even rate of return depends on the source of finance. For debt finance, it is simply the rate of interest, taken here to be 5.5 per cent (a typical nominal interest rate on 10-year Commonwealth bonds during the half-year to March 1999). For equity finance, the break-even rate of return depends on the effective rate of company tax, which is around 18 per cent (Abelson 1999, p. 13). The investors break even when the rate of return after company tax equals the interest rate: in that case, they have done just as well putting their money in equity as they would have by lending it. With an interest rate of 5.5 per cent, the before-tax rate of return must be 6.7 per cent for this to happen.

The next step is to take a weighted average of the before-tax rates of return on debt and equity. Assuming a gearing ratio of 60 per cent, following Abelson (1999, p. 13), the average equals 6.0 per cent (= $0.6 \times 5.5\% + 0.4 \times 6.7\%$).

Lastly, one deducts from the average before-tax rate of return the expected rate of inflation, about 1.5 per cent (see above). The end result is a discount rate of 4.5 per cent (= 6.0% - 1.5%).

The first step is to calculate, for debt and equity, the *nominal* rates of return before tax. The calculation pertains to the marginal private investments, which are break-even for the investors.

than private investment. As well, the benefits from the candidate project may partly accrue as public investment. The increase in national output due, say, to a road project could support public investment in schools, hospitals, and so on.

With public investment as the numeraire, the discount rate should be a marginal rate of return on public investment (as recommended by Quirk & Terasawa 1991).

The trouble is that public investments have widely varying rates of return, and evidence is scant for many categories. (Investments in public hospitals, for example, have rates of return to society that are rarely estimated, partly because of the problems in valuing human health.) Perkins (1994, p. 318) recommended econometric modelling of national production functions. However, only some of the benefits of public investments show up in national output. For example, the econometric estimates would not capture the visual amenity from a harbour bridge. Moreover, the econometric estimates are of highly doubtful reliability, even for what they purport to measure (chapter 12).

Consumption as the numeraire

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When consumption is the numeraire, the discount rate reflects intertemporal preferences in consumption. A discount rate of 4 per cent means that \$1.04 million of consumption a year from now benefits society exactly as much as \$1.0 million of current consumption. The discount rate over a consumption stream is called the social time preference rate (STPR).

The STPR embodies moral judgements about the welfare of different generations. Generational considerations are particularly important for projects with long lives. A common expectation, which broadly agrees with historical trends, is that future generations will be better off than people today. Accepting as well that the fortunate are less deserving of extra consumption than those less fortunate, this implies a positive STPR. The exact value entails moral judgements that are necessarily subjective.

Could one estimate an STPR in a reasonably objective fashion, were generational issues absent?

The question is not purely academic. Generational issues have limited relevance for short-lived projects (say, spanning three years). And, while most projects in transport BCA generate benefits for decades,

one might vary the discount rate over the project horizon, assigning a larger weight to intergenerational considerations for the more distant future (*The Economist*, 19 June 1999 p. 94). In addition, ignoring generational issues allows one to focus on other important considerations in valuing the STPR.

Generational issues would be absent were the current generations immortal and without successors. The social rate of time preference would then reduce to a personal rate: the rate at which someone is willing to substitute their own consumption next year for their own consumption this year. Nevertheless, the rate of time preference might still differ between government-funded consumption (like hospital services) and private consumption.

For private consumption, the rate of time preference would equal the interest rate, were it not for income taxes and government transfer payments. The tax/transfer system may reduce the rate of time preference below the interest rate (box 6.4). The system is so complex, however, that the appropriate adjustment to the interest rate would be subject to much uncertainty. Even harder to determine would be the rate of time preference over government-funded consumption.²⁹

Proposed values for the STPR have typically ranged from zero to 3 percent, according to Lind (1997, p. 51). Thus they tend to be well below the discount rates in common use, and often lower than the real government bond rate. Some have argued that such values are too low. Lind argues that future generations do not deserve the consideration that such values would accord, because they are likely to be much better off than current generations.

The choice of discount rate

The analysis of a riskless world has produced several candidates for discount rates. One of them, the social time preference rate, has proved a conundrum. The most popular choice would be the marginal rate of return on private investment, which should be measured from a societal perspective. But the social rate of return on private investment can differ from the private rate earned by investors; and such differences are hard to quantify.

²⁹ For private consumption, the sovereignty of individual consumers connects the rate of time preference with the interest rate. In box 6.4, the fictitious Wanda takes the interest rate into account in her consumption decisions. Interest rates also influence government consumption spending, but collective decisions are far harder to model than the decisions of individuals.

BOX 6.4 THE SOCIAL TIME PREFERENCE RATE AND THE TAX/ TRANSFER SYSTEM

Wanda has saved \$5,000 that earns interest at 4 per cent (real). After personal income tax, however, she earns interest only at 3 per cent. Wanda plans to cash in her savings a year from now to take a holiday.

If Wanda saved an extra \$50 now by curbing her current consumption, she could spend an extra \$51.50 on her holiday. But she does not consider this sacrifice worthwhile, which is why she is saving only \$5,000. Presumably, she would be willing to save the extra \$50 if the return were to increase sufficiently: that is, if the rate of return were sufficiently greater than three per cent.

Say that the rate of return would have to increase to 3.1 per cent, to induce Wanda to save the extra \$50. One might then say that her marginal time preference rate (MTPR) is 3.1 per cent. The MTPR is the rate at which someone is willing to make a small exchange of present for future consumption. In the sort of world being analysed — without risks and the passage of generations — the MTPR for each saver would be close to their after-tax interest rate. Strictly speaking, economists normally define the MTPR using calculus, to relate to infinitesimally small exchanges between present and future consumption. The MTPR thus defined should equal the after-tax rate of interest.

Similarly, for borrowers, the MTPR should be close to the interest rate, adjusted for taxes as appropriate. In Australia, however, personal loans generally do not earn tax deductions.

Government transfer payments can have similar effects to taxes, pushing the MTPR below the market rate of interest. For example, old-age pensions that are income-tested will, for some people, reduce the expected rate of return to saving during one's working years.

The real interest rate on foreign debt would probably be the best choice of discount rate by virtue of its measurability. At least, the best choice in the absence of all risk and when the focus is on national welfare.

If the net benefits of a project were to occur purely as changes in foreign debt, such a choice would also dovetail with theory. Foreign debt would be the natural numeraire, and the real interest rate on foreign debt the natural discount rate. The US Congressional Budget Office (CBO) adopted such a discount rate in the mid-I980s, on evidence that the costs of government investment occur mainly as increases in foreign debt (Hartman 1990, p. S-4). (The CBO measured the cost of foreign debt from the yields on US Government securities.)

One could still discount at the real interest rate on foreign debt, even when the net benefits take various forms, as they do in reality. To be rigorous, one would have to shadow price: to convert net benefits in other forms to foreign-debt equivalents. Harberger proposed a weighted average discount rate, to deal with the costs that take a mixed form. Others have proposed shadow pricing techniques that are more rigorous than Harberger's method, and which also take account of benefits in mixed forms.³⁰ For a discussion of these various techniques, see Feldstein (1972) and Perkins (1994, chapter 13).

Unfortunately, all these techniques are impractical. They require that elusive parameter, a sensible value for the STPR, plus information on the shares of benefits or costs that take each form. The shadow pricing techniques require more detail on the shares than does Harberger's method, and so are less practical (though more rigorous).³¹ Reliable estimates of the shares are generally unobtainable, even with recourse to national economic models (see chapter 9). And if national economic models were the solution, the shadow pricing techniques would be largely superfluous (as would Harberger's method.)

Feldstein (1972) explains the inadequacy of this approach. In one of his examples, two mutually exclusive projects have the same total cost and the same mix of cost between forgone consumption and forgone investment. The benefits of each project occur purely as increases in consumption. Since the costs of the projects are identical, the choice between the projects is between alternative consumption streams. For consumption streams, the relevant discount rate is simply the STPR, not a weighted average.

31 To illustrate, say that a new railway increases national output by \$100 million in its first year of operation, of which \$20 million comprises additional investment by railway-dependant industries. The additional investment, in turn, will yield returns that could take any of the macroeconomic forms: more consumption, less foreign debt, or further investment. The shadow pricing techniques would require shares for each, and various repeats of the same exercise — to figure out, for example, how much of the returns from reinvestment will be again reinvested, and so on.

³⁰ The Harberger approach produces a weighted average discount rate, based on the mix of resource costs. To illustrate, say that the STPR equals 3 per cent and that the social rate of return on private investment equals 6 percent. If forgone consumption meets one-third of a project's resource costs and forgone investment the rest, the weighted average discount rate equals 5 per cent (= (1/3) x 3 + (2/3) x 6). If the proportions are reversed, the discount rate falls to 4 per cent.

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Precisely for these reasons, the choice between the candidates for discount rates matters. If mixed forms *were* easy to deal with, the choice would be purely presentational. The discount rate would depend on the numeraire, which is simply a unit of accounting. Accounting in US dollars would not move an Australian balance sheet from black to red. Nor would a change in the numeraire affect anything substantive in a BCA, as others have also noted (for example, Little & Mirrlees 1974, p. 146).

In the final analysis, the choice of discount rate and the interpretation of the NPV entail an element of make-believe. One could imagine that the net benefits of a project occur purely as changes in foreign debt. Alternatively, one could imagine that the form of the net benefits is inconsequential. In this case, the distortions to the economy that could make this an issue, such as income taxes, are minor or somehow offset each other. There would then be minimal difference between the STPR, the marginal rate of return on private investment, and the real interest rate on foreign debt.

Other hypothetical assumptions are less practical. To assume that net benefits occur purely as changes in consumption would make the discount rate the STPR (Prest & Turvey 1965, p. 75). Likewise, assuming that net benefits occur purely as changes in private investment, the discount rate becomes the social rate of return on private investment. In either case, the relevant discount rate would be hard to measure, particularly the STPR.

Opposition to the STPR as a discount rate stems also from a less valid concern than practicality. The fear is that BCAs will approve projects that are inferior to alternative investments in the private sector. For a project to have a positive net present value, a normally sufficient condition is that the rate of return exceeds the discount rate. Now, the conventional wisdom is that the STPR is less than the rate of return on private investment.³² Say, for illustration, that the values are 2 and 4 per cent. Discounting at the STPR would then accord a positive NPV to a project that earns 3 per cent, even though a private investment would earn more (4 per cent). That a BCA should rate such a project favourably strikes many people as unacceptable (for example, Lind 1997, p. 53). Why proceed with the project when it consumes resources that could flow to higher-yielding private investments?

³² Recall that proposed values for the STRP are typically from 0 to 3 per cent, and that even a riskless private investment would have needed to earn 4 per cent in order to cover interest cost in the middle of 1999.

But Feldstein persuasively defended the STPR against this line of attack:

Several economists have advocated disregarding time preference completely and defining the discount rate [1] as the rate of return on private investment. They argue as follows: since the resources used in any public expenditure project could have been invested in the private sector where they could have earned a yield of i, public projects should not be undertaken unless they will obtain an equal vield. This argument reflects a basic ambiguity in the notion of opportunity cost. Economic textbooks often define opportunity cost as the value of resources in the best alternative use to which these resources *could* be put. This definition is implicit in the argument above. In fact, the actual opportunity cost of any resources is their value in the alternative use to which they would have been put. The two coincide in a perfectly functioning economy: if resources are not used in one activity they would be used in the most valuable alternative to which they could be used. But it is the very essence of the second-best problem that resources that could be invested with greater value are instead consumed. The economists who advocate discounting by the return on private investment fail to distinguish between the 'ideal opportunity cost' (what could be done with the resources) and the predictive opportunity (what would be done with them). (Feldstein 1972, pp. 319-320).

INVESTMENT RISK

And so now to the issue of risk, leaving behind the imaginary world of certainty.

Should the discount rate include a risk premium? Or should it equal the 'riskless' rate of interest, as proxied by the rate on relatively safe government bonds?

That BCAs should consider risk is sensible, because people dislike risk as a rule. People who are neutral about risk would be indifferent between earning \$40,000 with certainty and *expecting* to earn \$40,000 but with a chance of earning more or less than that. The apparent majority who are risk-averse, in contrast, would prefer the certain outcome. Yet even risk-averse people will be willing to accept some risk in exchange for a better expected outcome. A worker might, for example, be indifferent between earning \$35,000 with certainty and risky employment that pays \$10,000 or \$70,000 with equal probability. Although the earnings prospects in the risky employment have an expected value of \$40,000, their certainty equivalent to the worker is only \$35,000. In other words, the worker attaches a cost of \$5,000 to the earnings risks.

From a theoretical standpoint, however, raising the discount rate is the wrong allowance for risk. Among other possible distortions, it arbitrarily favours projects with benefits that grow slowly after a good start. Moreover, while the aim is to make a riskier project appear less attractive, it can have the opposite effect in special cases.³³ Box 6.5 illustrates how things can go wrong.

If still unconvinced, think of a project in which construction cost is the only risky outcome. To increase the discount rate for such a project would be a nonsensical allowance for risk. It would mark down benefits *after* construction for risks arising *during* construction. Since the benefits are certain, their present value, discounted at a 'riskless' rate of interest, properly measures them.

The Department of Finance (DoF) recommended that discount rates include a premium for 'market risk' only (DoF 1991, p. 57). Market risk stems from unanticipated fluctuations in the overall state of the economy. Such fluctuations affect the returns to investments generally, including transport facilities. Non-market risk, on the other hand, stems from factors that are more specific to particular investments. An example would be the possibility, on a particular road project, that geological conditions will prove better or worse than expected.

But premiums for risk of any type can create the sorts of distortions illustrated in box 6.5. Adding them to the discount rate is an unsatisfactory approach. Moreover, the distinction between market and other risks is ambiguous.

In concept, rigorous treatments of investment risks are possible. One could derive the probability of each uncertain outcome and measure net benefits in certainty-equivalents. That is, one could measure the risks and cost them, as in the above example of earnings risk.

The 'real options' approach associated with Dixit & Pyndyck (1994) treats investment risk in a sophisticated framework: it makes rigorous allowance for the value of flexibility in the face of future uncertainty. Lind (1997, pp. 57–58) discusses potential applications to BCA, using a flood-control project for illustration. To give a transport example, deferring construction of a highway may preserve

The problems with risk premiums in discount rates are widely recognised. Corti (1973) is good on this topic; see also, for example, DoF (1991, p. 64), Perkins (1994, p. 359) or US Office of Management and Budget (1996, p. 12).

BOX 6.5 DISCOUNT RATES WITH RISK PREMIUMS: A RISKY PROPOSITION

Compare two imaginary projects, each having effects over four years. Project A has a stream of expected net benefits, (-50.5, -50, +71, +80). Project B has a corresponding stream, (-90, -10, +50, +103). For concreteness, the units of measurement are \$M.

Considerable risk attaches to the fourth-year benefit. It has an equal probability of exceeding or falling short of its expected value by 60 M. (Project A thus offers even chances that the fourth-year benefit will be +20 or +140.) All other project outcomes are entirely predictable.

The benefits and costs are in the form of foreign debt. The resources for the projects come, in effect, from abroad, and the benefits go toward paying foreign debt. The interest rate on foreign debt is 4 per cent. Discounted at this rate, the projects have virtually the same expected NPV of about \$38.2 M. They also carry the same risk, due to the uncertainty of fourth-year benefit. For each project, the NPV will equally likely be +\$91.5 M or -\$15.1 M.

The projects are thus equally attractive. To see this another way, consider the change in foreign debt at project end. Each project offers an even chance that, by the fourth year, the foreign debt will be \$102.9 M lower or \$17.0 M higher.

Suppose that the discount rate is increased to 8 per cent to include a 4-percent premium for risk. Discounting at this rate would falsely show project A as superior, with an NPV of \$27.6 M compared to \$25.4 M for project B. Raising the discount rate favours project A for two reasons: most of its costs come relatively late, while a large portion of its benefits come relatively early.

Raising the discount rate to allow for risk can also, in some cases, increase the NPV, making a project look better. One such case is where the expected net benefits are initially negative, change to positive, and then back to negative. An example might be a nuclear power plant that has construction costs at the start, decommissioning costs at the end and benefits in between. Such a pattern appear to be rare in BCAs of transport projects, where the stream of net benefits normally has one change of sign: from negative to positive (benefits following costs).

But even when benefits simply follow costs, raising the discount rate can sometimes make a bad project look better. Specifically, when the NPV is negative at the original discount rate, increasing the discount rate can make the NPV less negative (though never positive). An example would be a project with costs of \$10 and \$300 in the first two years, followed by an annual benefit of \$6 for the next eight years. As the discount rate increase from 4 per cent to 8 per cent, the NPV of this white elephant increases, from -\$260 to -\$256.

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flexibility as to the exact route. Uncertainty about regional growth patterns and other matters make such flexibility valuable. The real options approach derives a monetary value for flexibility, and incorporates it into decision rules for investments — decisions on whether and when to invest. However, application of the approach requires as inputs probability distributions to quantify the uncertainties. (For a layman's introduction to the real options approach, see *The Economist*, 8 January 1994, p. 72.)

In practice, rigorous treatments of investment risk are rare and problematic. Even the first step — estimating the relevant probabilities — is a challenge, and few BCAs get as far as that. BCAs of transport projects seldom estimate, for example, the probabilities of alternative traffic levels.

Indicative of the problems in making allowances for risk is the experience of the US Congressional Budget Office. In the mid-I980s, the CBO decided to base its discount rate on the yield of US Government securities. Rather than building a risk premium into the discount rate, the CBO policy stipulated that uncertain income streams 'should be converted into certainty equivalents'. However:

In every case where this admonition was invoked, no one was quite sure what it meant or how to do it. For example, in the case of the government's proposed sale of the Great Plain's Coal Gasification Facility, the size of the future income stream was highly dependent on the projected price of energy. We could make a best guess about this price and about its distribution, but whose risk aversion were we to use to find the certainty-equivalent? (Hartman 1990, p. S-5).

The obstacles to a satisfactory treatment of risk might seem to justify discount rates with risk premiums as a second-best. The idea is that some correction for risk may be better than none, even if it introduces other distortions into the analysis.

But a risk premium in the discount rate makes no sense in some situations.

Consider the problem of allocating a fixed budget between competing transport projects — road projects, for concreteness. The BCAs for the various projects use the same discount rate, as is standard practice. For the allocation decision, the projects are ranked by benefit-cost ratio (BCR). Adding a risk premium to the discount rate does not differentiate between road projects with varying levels of risk. But it does affect the BCR ranking of projects in totally arbitrary ways that have nothing to do with risk.

Thus for one specific situation, the BTE can unequivocally recommend the 'riskless' rate of interest for discounting. This situation is where the decision is about how to allocate a fixed budget for a transport program and a single discount rate is used. In Australia, the riskless rate, as proxied by the real CBR-10, was about 4 per cent in the middle of 1999, as discussed earlier. (The adjustment for withholding tax is small enough to ignore.)

If, on the other hand, the decision is whether to increase a program budget through the adoption of another project, a risk premium in the discount rate would make some sense, as a crude allowance for risk.

But even when a risk premium makes some sense, an appropriate value is often elusive. The challenge, as was mentioned earlier, is to find private investments with a similar risk profile to the project under scrutiny.

The Department of Finance estimated that a discount rate in the order of 10 to 11 per cent would be appropriate for general government investments, were they subject to the same market risk as shares of stock (DoF 1991, p. 57). The estimate comprised a riskless rate of interest, which DoF set at 5 per cent, based on historical yields on Commonwealth bonds, plus a risk premium of 5–6 per cent. The risk premium was estimated from the Capital Asset Pricing Model, a popular tool of finance and economics. To allow for the lower market risk of general government investments, DoF reduced the risk premium to 3 per cent, thus recommending a discount rate of 8 per cent. The adjustment does not appear to have been model-determined, and no further explanation of its derivation was offered.

Another concern is that the acceptance of a 'second-best' solution will breed complacency. Discount rates with risk premiums are so entrenched in BCA tradition that they may strike the unwary as a firstbest solution. They are not. Developing better ways of incorporating risk into the calculations should be a priority for research on BCA.

To deal with risk through the discount rate can also invite other misuses of discount rates. If a project has environmental benefits that are too difficult to value, why not vary the discount rate to allow for them? Indeed, why not adjust the discount rate as a catch-all allowance for things too hard to value? Because such an allowance imposes arbitrary assumptions about the way in which unvalued net benefits vary over time and about their relationship to the net benefits that are directly valued. Further, how would one know how much to vary the discount rate? And, if opting for arbitrary allowances, why

opt for the discount rate rather than, say, adjusting construction costs?

BCAs should deal with environmental and other effects directly, assigning them an appropriate value for the year in which they occur. When this is not feasible, tinkering with the discount rate is hardly the solution.

IN SUMMARY

- Discount rates in current use in Australia mostly exceed the 10-year government bond rate, sometimes substantially. Much of the difference represents an allowance for risk.
- BCAs should make some allowance for risk, because people tend to be risk-averse. However, raising the discount rate is a crude allowance that can introduce other distortions to the analysis. Researchers should be seeking to develop better allowances that are also practical.
- When the problem is how to allocate program funding and a single discount rate is used, a risk premium in the discount rate is inadvisable. Discounting at the government bond rate would be more appropriate. To allow for risk would still be desirable, but the discount rate would be the wrong instrument.





The costs of a transport project are mainly in the consumption of resources: the labour, asphalt and so on. But additional costs to society can arise from public finance for a project. An increase in taxes will generally create social costs by distorting people's decisions. Income taxes can discourage people from working and saving, while indirect taxes (those not levied on personal income) can also do harm.³⁴ For example, taxes on financial transactions in Australia deter people from shifting their funds, and so limit competition between financial institutions.

Australian BCAs rarely quantify the social costs of increases in taxes or of other means of financing a project. As a remedy, Campbell (1997) proposed incorporating into BCAs of federally funded projects an estimate of the social cost of taxes. The estimate is based on the assumption that each extra dollar of Federal taxes imposes a social cost of \$0.24 by reducing labour supply (Campbell & Bond 1997). In effect, Campbell proposed to add 24 per cent to the conventionally measured costs.³⁵

35 The Federal Government would, under Campbell's proposal, fund only projects with a BCR of 1.24 or greater (assuming that the BCR does not incorporate the social costs of taxes). It would make exceptions for projects that have 'particularly desirable distributional effects' (Campbell 1997, p. 235).

³⁴ In theory, income taxes could also increase labour supply. Some people might react by working harder to make up for the loss of disposable income, a positive 'income effect' on labour supply.

Economists sometimes exclude the income effect on labour supply, when estimating the social costs of taxes (for instance, Findlay & Jones 1982). They reason that while taxes reduce disposable income, the expenditures funded by taxes increase it. Public investment in transport, for example, can increase national income; and, on higher incomes, some people will feel that they can afford to relax more — a negative income effect on labour supply that counteracts the positive income effect from taxes.

Some tax adjustments are already common in Australian BCA, but for reasons unrelated to project finance. Analyses often deduct taxes from the price of fuel when estimating the benefits from fuel savings. They may also make similar adjustments to other prices, such as those of motor vehicles. The prices after adjustment are what economists call 'shadow prices'.

After weighing Campbell's proposal, this chapter briefly discusses shadow pricing for taxes: the rationale, the adequacy of current Australian practice and the implications of the imminent GST. Chapter 6 discusses the implications of taxes for the choice of discount rate.

THE SOCIAL COSTS OF TAX FINANCE

Several considerations militate against Campbell's proposed adjustment and any other routine adjustments for the same purpose.

Taxes are only one source of public finance

Governments can finance a project by means other than raising taxes. They can reduce other public expenditure, borrow or increase government charges.

Reducing other public expenditure

Governments are likely to finance many projects simply by spending less in other areas, especially with the current political mood favouring small government.

Indeed, many BCAs concern the allocation of a predetermined program budget. In such analyses, funding for one project simply means less funding for other projects in the program. The social costs of tax finance are then irrelevant to the decisions being analysed.

Public borrowing

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A common notion is that public borrowing is taxation in disguise: that the government will ultimately have to increase taxes to repay principal and interest (for example, Campbell 1997, p. 231). But governments also have other ways of managing debt.

The Federal Government can repay lenders by printing more dollars ('money financing'). Technically, money financing involves the sale of Federal debt instruments to the Reserve Bank of Australia ('monetizing the debt'). Money financing also imposes social costs, notably by increasing the rate of inflation.³⁶ However, these costs will differ in magnitude from those of tax finance.

Governments can also repay lenders through further borrowing ('debt financing'). In the extreme, reliance on debt financing continually avoids the need to raise taxes. Suppose that a government initially finances a project by borrowing \$1 million for one year at 10 per cent interest. The government meets its liability when payment comes due by borrowing from the public another \$1.1 million on the same terms. The next year the government borrows from the public another \$1.21 million, and so on. Public holdings of the project debt increase each year at the rate of interest. Such pure reliance on debt financing can be viable with sufficient economic growth.³⁷ Even when unviable, a lesser reliance on debt financing can still reduce the need to raise taxes.

A sale of public assets is yet another option for financing public projects, but this is similar to borrowing.

Increasing government charges

Increases in government charges can have quite different social costs from increases in most taxes. Indeed, where governments undercharge for some service, an increase in charges could yield a social benefit rather than a cost. Congestion pricing for public roads is a case in point. In some States, the imposition of economically efficient congestion charges in the capital city would yield enough revenue to fund road expenditures for the entire State (BTCE 1997c, table 4, pp. 20–21).

³⁶ Inflation reduces the real value of cash holdings (and of cash-like assets, such as undeposited cheques). So it makes cash less attractive relative to other assets that hold their value against inflation. As inflation rises, people attempt to reduce their holdings of cash by spending it more frequently, at some cost in inconvenience. A stark example is provided by Landsberg (1993, pp. 68–69). 'In the Hungarian hyperinflation of 1948, workers were paid three times a day and their spouses were employed full-time running back and forth between the workplace and the bank, trying to deposit paychecks before they became worthless.' The banks, presumably, were offering interest rates somewhere near the rate of inflation. (Otherwise, they would have had a hard time attracting customers — people could have done better by acquiring other assets, including real assets such as food and automobiles.)

³⁷ Economic growth enhances the government's revenue base and public confidence in its credit-worthiness. Economic growth also increases the demand for financial assets, including government debt. For more discussion, see Dornbusch & Fischer (1990, pp. 612–615).

Transport investments have diverse effects on government revenues

Even for projects that are purely tax-financed, estimation of the needed increase in taxes can become complicated. Projects have diverse effects on government budgets.

The improvements that result from transport projects generally boost national output, which adds to tax revenue. The additional revenue reduces the amount by which the government needs to raise taxes to finance the project.

But improvements to the transport network can also affect demand for petrol, which is highly taxed. Many road projects reduce the amount of petrol required for a given road transport task, and so may reduce the revenue from petrol taxes.

Construction and maintenance of transport projects also have mixed effects on tax revenues. They generate some tax revenue through their use of taxed inputs, but they divert resources from other production that would have generated tax revenue too. Moreover, the loss of other production imposes some restraint on national spending, which occurs partly through sacrifice of investment. The forgone investment would have generated future tax revenues by boosting national output, just as a transport investment would.

Estimates of the social costs of taxes vary widely

Estimates of the social costs of taxes in Australia vary widely. The estimates presented below are of marginal social cost: the social cost from a small increase in the amount of tax revenue raised. They are expressed as the ratio of social cost to revenue gain; an estimate of 0.20 means a social cost of 20 cents on the extra tax dollar.

Han (1996) obtained estimates of marginal social cost that were sensitive to changes in assumptions: for example, the estimates for the payroll tax varied from 0.38 and 0.60. The estimates nevertheless had a stable ranking across the types of taxes modelled, with the payroll tax being the most distortionary. Taxes on labour income came out the least distortionary, with a marginal social cost of only about 0.11. The difference in estimates between payroll and

labour income taxes is, however, hard to reconcile with Han's assumptions. $^{\ensuremath{\mathsf{38}}}$

Diewert & Lawrence (1997) found that taxes on capital income create quite large social costs. According to their estimates, the marginal social cost increased over the decade to 1994, finishing at 48 cents on the dollar. The authors attributed the trend to 'the introduction of capital gains taxes, increasing reliance on transaction taxes and the progressive tightening of the tax base'. In the study's econometric model, taxes on capital income create social costs by discouraging investment; the authors plan additional modelling that will allow taxes to discourage saving as well (personal communication).

Campbell & Bond (1997) estimated that a marginal social cost of between 0.19 and 0.24 arises from the effects of taxes on labour supply. Their estimates combine the effects of income and indirect taxes. An indirect tax can affect labour supply somewhat like an income tax, by reducing the returns to work effort. Indirect taxes can push up consumer prices, which reduces the purchasing power of labour income.

In Albon (1997), estimates of the marginal social cost of State taxes varied substantially: they were only between 0.10 and 0.22 for taxes on wine, compared with 1.31 for taxes on spirits. These estimates do not reflect externalities from alcohol consumption, such as people being hit by drunk drivers. (Nor do they reflect that some people may consume more alcohol than is good for them.)

Estimates of marginal social cost can vary greatly even for a given tax. For taxes on labour income, the estimates varied from 0.23 to

The other categories of taxes in Han's model were import tariffs, export duties and a 'consumption tax' (wholesale sales tax and the like). Taxes on capital income were not modelled and other taxes were assumed, with some loss of realism, to have no effect on the economy's stock of capital. The analysis followed that of Diewert & Lawrence (1993), who estimated the social costs of taxation in New Zealand.

In representing both taxes as proportional to total labour income, Han abstracts from complications such as exemptions to payroll tax. Apart from the rate of tax, the only detectable difference between his modelling of these taxes is who formally pays them—the workers (labour income tax) or the employers (payroll tax). Han also abstracts from tax non-compliance and administration costs, and assumes the labour market to be in a perfectly competitive equilibrium (demand equals supply at the prevailing price of labour). With all these simplifications, it is hard to see how marginal social cost could differ between payroll and labour income taxes. The offered explanation (Han 1996, p. 23) was unclear to both the BTE and Albon (1997, p. 285).

0.65 in an Australian study (Findlay & Jones 1982, p. 261) and to a similar extent in an American study (Ballard & Fullerton 1992, p. 127). Contributing heavily to this variation is uncertainty about the magnitudes of labour supply responses to changes in taxes.³⁹

For taxes with complex structures, such as personal income tax, another uncertainty is how the tax will be restructured to raise revenue. The social cost can vary considerably, depending on the details of the restructure (Findlay & Jones 1982, p. 261).

Australia's Federal system of government further complicates the picture. A project can affect the budgets of various governments, including those that do not contribute funding. For example, a project funded by a State Government could affect the Federal Budget through impacts on the national economy. In theory, the project could induce each affected government to adjust its taxes. Since the types of taxes differ by level of government, to estimate the overall social cost of such changes in taxes would require quite a detailed analysis.

What to do?

To recapitulate, the social costs of public finance for a project are quite difficult to estimate.

For most projects, there is much uncertainty about the extent to which funding will come from taxes; governments can fund projects in other ways, such as reducing their other expenditures. Even when tax finance is assumed, there remain the questions of what types of taxes are involved, and how much they need to be increased to finance the project (taking account of the project's various effects on government budgets). Nor does the ambiguity stop there. Even for a known type of tax and amount of increase, estimates of marginal social cost can vary widely.

Speculative estimates of the social costs of public finance have appeared in some BCAs. An analysis of Norwegian road investments,

³⁹ Evidence on labour supply responses is more abundant for the US than for Australia. Killingsworth & Heckman (1986) reviewed evidence on the labour supply of American women and found huge variations in the estimates of wage and tax effects. A subsequent study attempted to narrow the range through extensive testing, and cast doubt on many of the larger estimates obtained earlier (Mroz 1987, p. 795). See also *The Economist* 24 August (1996, p. 64) and Auerbach and Slemrod (1997). A limitation of the available evidence is the almost exclusive focus on hours worked and labour-force participation: labour supply also depends on the level of effort during work hours and on the acquisition of skills.

for example, drew on estimates of the marginal cost of public funds in that country that varied from 0.2 to 0.8. As an 'approximate value', it chose 0.25 (Braathen, Hervik & Nesset 1996).

Because of these uncertainties, routine adjustments to BCA to incorporate the social costs of tax finance seem inappropriate. Campbell's (1997) proposed adjustment would also conflict with this report's stance on employment effects. Chapter 5 recommends that BCAs not value the aggregate employment effects of transport projects (which proponents often see as positive). Campbell would value a decrease in aggregate employment resulting from tax finance for a project (through changes in labour supply).

A special case is where a government specifies a tax or charge as the source of project finance. For example, the Western Australian Government designated an increase in vehicle license fees to fund road spending under the Transform WA plan (Burns 1998, p. 4). Such designations simplify the estimation of the social cost of project finance, although a reliable estimate for the financing instrument involved could be elusive.

SHADOW PRICING FOR TAXES

Taxes as transfers

Taxes can distort economic decisions, as by discouraging work effort. They also entail burdens in administration and compliance, including nuisance to the taxpayer.

Although taxes create social costs in these ways, the amount of tax collected does not, in itself, represent a social cost or benefit, any more than does a voluntary contribution to charity. The amount of a voluntary contribution represents a transfer of income from donor to the recipient, rather than a net increase in society's income. Likewise, the amount of the tax collected is a transfer between segments of society: from taxpayers to government.

The distinction between transfers and social costs underpins the conventional adjustments for taxes in transport BCA.

Typically, the most important adjustment is for fuel taxes. Savings in fuel are a significant benefit of many transport projects. Conventional practice is to value the savings at prices excluding tax. The tax is excluded because it represents a transfer rather than a social cost. Suppose that a road improvement saves a car commuter \$2 in daily petrol expense. While the commuter benefits by \$2, the public sector loses fuel tax revenue — about \$1.20 at current rates of

tax — and this reduces the services that governments can provide.⁴⁰ Hence the benefit to society reduces to 0.80.

BCAs may also adjust for taxes on transport inputs other than fuel. A BTE model for evaluating rural road investments (RIAM) excludes taxes on inputs such as tyres and vehicle parts. (An exception is the payroll tax on transport labour; see box 4.3.) Excluding taxes from the costs of inputs to transport projects is less common, partly because of the lack of data on input composition. An example of this practice is the exclusion of taxes on fuel for railway construction (BTCE 1994a, p. 54).

Gaps in shadow pricing

BCAs of Australian transport projects are incomplete in their shadow pricing for taxes. (Analyses that use a national economic model may be fairly complete, but are still uncommon.)

The gaps in shadow pricing for taxes can represent omitted costs as well as benefits. They are not likely to matter greatly, because few goods and services are highly taxed. However, there is little excuse for omitting benefits or costs that are readily measurable, and recent tax reform should simplify measurement.

To illustrate an omitted benefit, recall that transport improvements boost national output, which increases commodity tax revenue. The additional revenue is a benefit because it can fund more public services or allow compensating tax relief. Yet it does not show up in standard BCA calculations.

Savings in business travel time, for example, are conventionally valued at some measure of labour cost. A more complete valuation would also include commodity taxes on labour's output (chapter 4). Imagine that a road improvement enables the same freight task to be performed with one less truck driver and that the now-surplus driver ends up working in a vineyard. The benefit to society includes the taxes on the resulting increase in wine output (box 4.3).

In the past, lack of uniformity in commodity tax rates hindered the estimation of such benefits. Labour released from transport could have ended up producing outputs that were either highly taxed (like wine) or lightly taxed. Likewise for savings in transport resources other than labour, like fuel. Savings in fuel allow people to spend

⁴⁰ For this calculation, the commuter buys unleaded petrol in Sydney. The price is 71.3 cents per litre, the Sydney average for the June quarter 1998 (ABS 1998a, p. 3). The tax on unleaded petrol was 42.8 cents per litre.

more on other goods or services, which have varied considerably in their tax rates.

However, the recently enacted goods and service tax (GST) has made commodity taxation in Australia more uniform and hence more tractable within BCA. Other countries with a comprehensive GST allow for the tax in their BCA guidelines, and Australia should do the same. Gan (1995) prepared guidelines for the Government of British Columbia, where a 14 per cent tax rate resulted from a comprehensive GST and producer services tax in combination. Other taxes pushed the rate on fuel to 90 per cent. The recommendation for valuing fuel savings was thus to multiply the pump price by the factor 1.14/1.9. Deflation by the denominator excludes the taxes on fuel, as do Australian BCAs. The numerator adds the taxes on other spending that savings in fuel allow.

IN SUMMARY

- The funding requirements for public investments in transport can lead to tax increases. Higher taxes create social costs by distorting economic choices, including how much to work and how much to save. Few of the transport BCAs conducted in Australia estimate these costs, an omission that is hard to remedy. Consistency between BCAs on this matter, as on others, is important.
- Transport BCAs conducted in Australia have also omitted certain costs and benefits associated with changes in commodity tax revenue. The recent enactment of the GST should make it easier to measure these costs and benefits.

8

IMPERFECT COMPETITION: HOW RELEVANT TO TRANSPORT BCA?

If the economy were perfectly competitive, economists would have much easier tasks.

In particular, economists would not need to rack their brains about unemployment. In perfectly competitive labour markets, demand equals supply at the prevailing price of labour (the market clears). Anyone willing to sell their labour services at that price can find employment.

Imperfect competition causes unemployment in the real world. Collective bargaining, or government interventions such as legal minimum wages, can keep the price of labour above the marketclearing level. These arrangements place limits on competition. Unemployed workers cannot compete for jobs by offering to work for less than established pay levels or conditions.

Paucity of information also limits competition in labour markets. By definition, perfect competition features perfect information. Everyone is completely informed about the characteristics of the good or service being traded and the prices being offered. In actual labour markets, employers and workers have only partial information, and the search for more information entails unemployment. A worker who suddenly becomes retrenched is likely to be unemployed for a period, while he learns about job opportunities and potential employers investigate his qualifications.

Whether to value employment-creation benefits (chapter 5) is an issue mainly because of community concerns about unemployment, which would be absent were labour markets perfectly competitive.

In product markets, limits to competition can arise from increasing returns to scale. If firms can reduce their unit cost by increasing their level of output, big firms will be able to produce more cheaply than

smaller competitors. In the end, a few big firms may gain the lion's share of the market. In contrast, perfect competition features a large number of small producers, each with a negligible market share.

Conventional BCAs of transport projects largely ignore imperfect competition in product markets (chapter 3), at least outside the transport sector.⁴¹ For example, a highway BCA would rarely examine the degree of competition within a highway-using industry. The assumption, usually implicit, would be perfect competition.

Conventional analyses thus ignore some benefits that arise when a transport improvement strengthens competition (chapter 3). Drawing on the 'new economic geography', Venables and Gasiorek (1998) suggest that these omitted benefits are large. This chapter assesses their argument and evidence.

This chapter also considers another way in which imperfect competition can bias conventional BCA measures of benefit. Speaking of highway investments, Mohring & Harwitz (1962, pp. 35–36) argued that the 'elements of monopoly' in the economy cause the conventional measure to understate benefits The conventional measure is the change in transport consumer surplus, or CTCS (chapter 2).

The problem that Mohring and Harwitz identified relates to transport used for market production. Such usage would include, for example, freight operations for the distribution of manufactures (marketed products). It would include a commercial bus service as well (also produced for the market). In contrast, tourists travelling in their own cars are not engaged in market production.⁴²

⁴¹ Competition is limited in many transport markets. For example, markets for rail services in Australia feature only a handful of providers, and usually just one for a given service. In line with this, BCAs sometimes depart from perfect competition in their assumptions about transport prices. An analysis of the Channel Tunnel used game theory to model price-setting strategies among competing cross-channel operators (the tunnel and the ferries; Manning & Szymanski 1989, pp. 217–218 and appendix A). Such formal modelling of price determination appears to be unusual, however; allowances for imperfect competition in transport more often take the form of impressionistic assumptions (for example, BTCE 1996b, pp. 10–11).

⁴² One might describe such activity as 'non-market production' (in the economics literature, also 'household production'). The tourists combine various inputs — fuel, their own time, vehicle capital and so on — to produce a transport service for their own use rather than for the market. The transport service, in turn, is an input to the non-market production of a tourist trip, along with other inputs like food and lodging.

IMPLICATIONS OF MONOPOLY (THE MOHRING-HARWITZ ARGUMENT)

A brief review of some points from chapter 4 will help explain the implications of monopoly.

Once more: a road improvement somewhere reduces crew requirements for a freight operation by one worker; the worker who would have driven trucks is now employed somewhere else.

What is the benefit to society?

The benefit is the value of what the worker produces in the alternative employment. A conventional measure of this benefit is the average labour cost of truck drivers (box 4.3). However, this valuation procedure omits commodity taxes, which in principle should be included.

To illustrate, suppose that the worker would have cost their employer \$800 per week as a truck driver. The assumption in the conventional measure is that the worker will produce \$800 worth of output per week in alternative employment. But if the alternative employment were in a vineyard, the value of the worker's output would include the taxes on the wine. If the taxes amounted to, say, \$30 per week, the benefit to society from the additional wine should be valued at \$830 per week (overlooking that some people may drink more than is good for them).

The conventional valuation procedure also ignores the implications of imperfect competition. The underlying assumption is that industries are perfectly competitive.

To see this, suppose that someone who would have driven a truck works, instead, for a monopoly producer. The monopolist operates for profit and faces no regulations that would limit its market power. Also, the monopolist produces a single product, a 'widget', for which it charges the same price to all customers. In this situation, the exercise of market power leads to a price that is higher than cost considerations would warrant. The excess of price over marginal cost is the monopoly price mark-up. At the high monopoly price, consumers demand fewer widgets, reducing production below the level that would be socially optimal.

From a welfare perspective, the monopoly on widgets would be similar to a tax on widgets. Both push the price of a widget above its marginal cost of production (the cost of producing an extra widget). True, the wedge between price and marginal cost accrues to the government as tax revenue in one case, and to the monopolist in

the other (as 'excess profit'). However, this difference concerns the distribution of benefits within society rather than level of societal welfare. Exactly who receives a benefit is immaterial when the aim is to measure the overall benefit to society.

Intuitively, then, monopoly profits and commodity taxes require similar adjustments when valuing the benefit from a reduction in truck crew requirements. The adjustment for commodity taxes raises the value of this benefit above the cost of employing a truck driver (as in the wine example). An adjustment for monopoly profits would do the same. One would estimate the monopoly price mark-up multiplied by the output gain from an additional worker. The result then would be added to the cost of employing a truck driver (appendix I).

An adjustment worth making?

Adjustments for monopoly profits are limited in their practicality. They require information about where the employment released from transport shifts to. Does the employment shift to industries that are strongly competitive or quasi-monopolistic? Such questions are usually hard to answer.

Adjusting for monopoly profits would be harder than adjusting for commodity taxes. Commodity tax rates are public knowledge; the profits to a monopoly from employing additional workers would be private, commercially sensitive information. For outsiders to glean something about this requires considerable effort and ingenuity.

Apart from lacking practicality, an adjustment for monopoly profits would appear to have limited relevance.

Competition in many sectors of the Australian economy is keen. In tourism, businesses in popular destinations compete strongly with each other as well as with businesses in alternative tourist destinations. To take another example, there are myriad producers for many agricultural commodities.

Impediments to competition are much less important than they once were. Australian industries are facing stiffer competition from abroad because import tariffs and other barriers have declined. Physical distance provides businesses with less protection from competition than previously, as the transport network in Australia has improved.

In addition, competition has spread into infrastructure sectors that once were government monopolies, such as electricity. Victoria has privatised the generation and distribution of electricity, in which several companies now compete. A national electricity grid is being

developed to allow competition between generators in different States. Pro-competitive reforms in the Australian economy have gathered pace with the adoption of a national competition policy following the 1993 Hilmer report (King 1997).

National competition policy curbs the abuse of market power in sectors where competition remains limited. Some infrastructure services may be natural monopolies for technological reasons, but national competition policy sets a framework for negotiating access to such services. For example, in the electricity sector, it governs the access of distributors to the transmission network. The regulation of access to essential facilities limits the ability of the monopolists to price above marginal cost. Mere monopoly, without a significant price mark-up, does not require special adjustments in benefit-cost analysis.

An adjustment for monopoly profits has limited relevance for yet another reason. Limits to competition in Australian industry often take the form of oligopoly — dominance by several large producers — rather than monopoly. Two companies (Qantas and Ansett), for example, dominate the domestic passenger segment of the aviation industry. Oligopolists sometimes attempt collusion to keep their prices high. When they succeed, the industry functions like a monopoly, and the presence of oligopoly would call for the same sort of adjustment in BCA as would unregulated monopoly.

In reality, such collusion is difficult to maintain. Government policies such as the Trade Practices Act create obstacles for would-be colluders. So does human nature, which tempts producers to cheat on agreements (such as the agreements by OPEC members to limit oil production).

Because of the obstacles to collusion, oligopoly would call for a different adjustment in transport BCA than would monopoly. Exactly what sort of adjustment is unclear, however, since economists have not settled on a general theory of oligopoly (despite some recent progress: *The Economist*, 2 May 1998, pp. 66–68). Like other game-theoretic situations, an oligopoly defies neat formulations.⁴³

⁴³ Jara-Diaz (1986) treats the case of duopoly, in examining the ability of the CTCS to measure benefits from transport improvements. In his duopoly model, two producers make the same product in different regions. One-way trade in the product occurs between the regions. (One region meets part of its demand for the product by importing from the other.) The game-theoretic formulation is simplistic: each producer sets his price on the assumption of no price response from his rival. (continued on page 94)

Witness, for example, the controversy as to the prevalence of 'predatory pricing', under which companies attempt to drive out competition by slashing their prices (*The Economist*, 10 July 1999, p.78).

The problems in modelling oligopoly have hindered the estimation of the welfare effects of government policies, both in transport and other areas. The literature on trade protection policies, such as tariffs, illustrates the difficulty. Studies that estimate the welfare effects of these policies often assume perfect competition. But some of the key protected industries, such as motor vehicle manufacturing, resemble oligopolies. Studies that have modelled trade protection under imperfect competition have displayed disparate approaches and findings. They have, in the words of Dixon & Parmenter (1995, p. 83), 'failed to allow a useful narrowing of the range of possible estimates of the costs of protection'.

TRANSPORT IMPROVEMENTS AS A SPUR TO COMPETITION

Critiques of transport BCA have included several arguments about pro-competitive effects.

The classic argument is that transport promotes competition among producers outside the transport sector. Distance insulates against competition to some extent, but distance effectively shrinks as transport improves. With transport costs lower, producers in different locations compete more strongly and society benefits. Conventional measures of benefit such as the CTCS omit some or all of these benefits from stiffening of competition. But with competition already strong in much of the Australian economy, this would probably be a minor omission for most BCAs.

Transport improvements can also affect the level of competition by affecting industry choices of location.

⁴³ The conclusions that Jara-Diaz reaches are consistent with those here and in chapter 3. He finds that the performance of the CTCS depends on the relative degree of 'monopoly power' of the two producers. (Although the situation is literally duopoly, each producer has some monopoly power over its own region due to the protection of distance.) Monopoly power is measured by the excess profit per additional unit of production. Jara-Diaz finds that if the producers have equal monopoly power, the CTCS will understate benefits. This is the same result that Mohring and Harwitz obtained for the case of pure monopoly. Only if monopoly power is greater in the importing region could the CTCS overstate benefits in Jara-Diaz's model. This corresponds to one of the cases in the tourism example of chapter 3 (Example B).

Venables & Gasiorek (1998) present a model of a hypothetical economy, where improvements to road freight transport affect the regional distribution of industrial production. They emphasise the possibility that firms in an industry will tend to locate closer together as transport improves and, in the extreme, will agglomerate in a single region. Such concentration would expose each firm to greater competition from others. The heightened competition, in turn, would benefit the industry's customers, with products becoming cheaper or improving in quality or variety. Venables and Gasiorek observe that conventional road BCAs ignore these and other pro-competitive effects.

How might an improvement in road freight transport cause an industry to agglomerate in a region? Venables and Gasiorek explain this by drawing on ideas from the 'new economic geography' literature.⁴⁴ At the same time, they caution that formal development of these ideas is still in its infancy. Perhaps for this reason, their explanation is not altogether easy to follow, despite sounding somewhat plausible.

The explanation appears to hinge on the existence of trade between firms in the same industry. An example of such trade: a computer manufacturer uses computers in its operations, and purchases some of these computers from other manufacturers. Within some industries, trade links of this sort can be strong.

Venables and Gasiorek seem to be saying that when intra-industry trade is strong, an improvement in road freight transport can trigger agglomeration. Agglomeration will increase competition within the industry, which benefits the industry's customers. But when trade within the industry is strong, a major customer is the industry itself. So increased competition within the industry reduces the industry's own input costs. (The computer manufacturer can buy from other computer manufacturers more cheaply.) Venables and Gasiorek argue that the reduction in input costs makes agglomeration attractive to individual firms. They also observe that agglomeration has a down side: with the industry clustered in one region, distances to dispersed customers outside the industry will lengthen, adding to transport requirements. Thus they argue that transport

^{44 &#}x27;This literature argues that the interaction between market imperfections of various types and transport costs (or more generally the costs of doing business across space) are important determinants of the location of industry, and of economic activity generally' (Venables and Gasiorek 1998, p. 1). For the arguments in detail, see Krugman (1998).

requirements will deter agglomeration until the cost of transport becomes small enough.

The agglomeration argument of Venables and Gasiorek appears to be incomplete. Its essence is that the cost of agglomeration — a larger transport task — becomes less important as transport costs fall. But the same should be true of the benefit of agglomeration, the increase in competition. As transport costs fall, a dispersed industry becomes more competitive, even without any changes in firm location. (Distance imposes fewer barriers to competition as transport improves.) Hence there is less scope for further strengthening of competition through firms locating close together. If better transport reduces both the benefits and costs of agglomeration, its overall effect on the propensity to agglomerate is ambiguous.

If better transport encourages industries to agglomerate, as Venables and Gasiorek argue, the resulting boost to competition may nevertheless be a minor consideration in most transport BCAs. At the risk of belabouring the point, competition in the Australian economy is already fairly keen.

Another argument that has appeared in critiques of transport BCA concerns competition between modes (see, for example, IRU 1993, pp. 17–18). Increased competition from one mode may spur operators of other modes into becoming more efficient. In Australia, there appears to be significant scope for the rail industry to improve its efficiency, despite recent progress. In 1993–94, the operating cost for the industry's freight operations exceeded what could be achieved by adoption of world best practice by an estimated 24 per cent (BIE 1995).⁴⁵ Conceivably, future investments in the road network will force efficiency gains from the rail industry, gains that would be extremely difficult to estimate in a BCA. An evaluation of the European Channel Tunnel allowed for efficiency gains in a competing mode, ferries, but the magnitudes were purely illustrative (Kay, Manning & Szymanski 1989, pp. 225–226).

IMPERFECT COMPETITION AND DISCOUNT RATES

Chapter 6 explores the choice of discount rate in transport BCA. The conventional choice is a typical rate of return on private investment: the idea is that the investment under scrutiny, which

⁴⁵ In contrast, the Australian road freight industry is, by world standards, highly efficient (BIE 1994, p. 53).

is normally public, should earn returns that are as good as those from private alternatives.

Private investments can have benefits or costs for parties other than the investors. A discount rate based on the rate of return to private investments should be a social rate that includes these broader benefits and costs. Measuring a social rate is quite difficult, however, so the discount rate is usually some measure of private rate of return to the investors.

Imperfect competition is among the sources of divergence between social and private rates of return. The arguments are the same as those considered above, regarding imperfect competition and benefits of transport investments.

One of the above arguments was that transport investments enhance competition, and that conventional measures of benefit fail to reflect this benefit adequately. But the same could be said about some alternatives to transport investments. Suppose that an investment in transport displaces investment in telecommunications. Better communication services also promote competition in the economy by overcoming the 'tyranny of distance'. For example, better video conferencing services will extend the market reach of companies that rent these services. Because of the benefits from increased competition, the private returns to a telecommunications investment could understate the social returns.

The other main argument, taken from Mohring and Harwitz (1969), concerned the implications of classic monopoly (without regulation or price discrimination). As those authors caution, monopoly complicates the measurement of benefits from investments generally: this also applies to transport. The existence of classic monopoly would suggest that private returns to investment understate social returns. Suppose that a transport investment displaces investment by a monopolist. The displaced investment could have benefited the monopolist's customers, through price reductions, improvements in product quality or better access to products. The private rate of return on the investment would reflect the benefits to the investor, but not to the monopolist's customers.⁴⁶

⁴⁶ The investor being a monopolist is merely for illustration. As long as classic monopoly exists somewhere in the economy, one could argue that private returns will tend to understate social returns. Suppose that a transport investment displaces investment from a perfectly competitive industry. The displaced investment is labour-saving, and the released labour flows to a monopolistic industry. The labour savings would have a social return greater than the private return (the cost savings to the investing industry). Appendix I gives the basis for this conclusion.

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So the arguments about imperfect competition cut both ways. They suggest some underestimation of benefits from transport investments *and* some underestimation of the discount rate, at least in the conventional approach to discounting. The desired discount rate under the conventional approach is the social rate of return on private investment. But the above arguments, taken on their own, suggest that the social rate exceeds the private rate, which is what discount rates in practice generally measure. A discount rate that is too low makes projects look better than they really are.⁴⁷

Two caveats:

First, imperfect competition is hard to analyse, and the preceding arguments rest on stylised paradigms. If imperfect competition took only the form of classic monopoly, it would indeed push the social returns to private investments above the returns to the investors.

For more realistic forms of imperfect competition, such as oligopoly, differences between social and private returns are less predictable. Granted, private investors will capture only some of the benefits of their investment, with other benefits accruing to customers. But corresponding to the 'uncaptured' benefits are costs that the private investors do not bear. Investment by one firm can disadvantage competing firms — the losses to the competing firms are 'uncaptured' costs. Under imperfect competition, it is conceivable that uncaptured costs of some investments will exceed uncaptured benefits, so that social returns are less than the private returns.⁴⁸

Second, imperfect competition is only one source of divergence between social and private returns to investment. While it might often push social returns above the private returns, other influences could have the opposite effect. For example, private investment in a factory could generate costs in pollution. In some cases, the overall returns to society could be less than the returns to investors.

⁴⁷ Whether the social rate of return on private investment is the 'right' discount rate is another matter. This is discussed in chapter 6.

⁴⁸ Under perfect competition, and abstracting from taxes and externalities, the uncaptured costs and benefits cancel out, so the private returns to the investment equal the social returns. On the other hand, social returns exceed private returns under classic monopoly. (Appendix I discusses these points.) This might seem to suggest that in situations of intermediate competition — less than perfect but better than monopoly — the social returns will somewhat exceed the private returns. However, the economics of imperfect competition are not yet well enough understood to allow this conclusion.

Other critiques of BCA

The above arguments are at variance with the critique of BCA offered by Docwra & Kolsen (n.d., pp. 77–8). The critique is couched in terms of roads and has found acceptance in Austroads (1997a, pp. 57–59), but the potential scope is more general.

Docwra & Kolsen stress that BCA differs fundamentally from the appraisals that guide private investment decisions. The private appraisals focus on profit, BCA on the benefits for society (the social returns).

More arguably, the authors suggest that the social returns to private investment exceed the returns to the investors (the profits). As justification, the authors draw a connection to the degree of competition in the economy.

Finally, the authors reject BCA as a means of determining the optimal level of road expenditure (economy-wide). Allegedly, BCA exaggerates the returns to road investments relative to alternative investments in the private sector (that the road projects could displace). The reasoning is that BCA measures benefits more broadly than do private financial appraisals—total benefit to society versus profit to investors. The role for BCA in road planning, as the authors see it, is to help allocate a predetermined road budget between alternative projects.

To so restrict the role of BCA would be unwarranted. Benefit-cost analysis has the potential to allow for divergences between social and private returns to private-sector investment. One way of doing so is through the choice of discount rate. In practice, lack of information tends to deter such adjustments, and discount rates are usually based on private returns. But this does not necessarily bias BCA in a particular direction. While imperfect competition may often push the social returns above the private returns, other factors, such as environmental damage, can have the opposite effect. The direction in which private and social returns typically differ is an empirical question.

Moreover, the alleged bias in BCA, to the degree that it exists, may well be opposed by other biases. Recall the double edge of imperfect competition. It may push the social returns to private investment above the returns to investors, leading to underestimation of discount rates. But it can also lead to underestimation of the benefit stream from the project being evaluated.

ECONOMIES OF SCALE

Another criticism of transport BCA is that it understates benefits by ignoring scale economies outside transport (for example, Applied Economics 1995, p. 64; TNZ 1994, pp. 3–5).

The distinction between internal and external scale economies helps to evaluate this criticism.

Internal scale economies exist when a company can reduce its average cost by increasing its output. They are an issue in BCA only to the extent that they undermine competition.⁴⁹ Internal scale economies *may* lead to a breakdown of competition. And *some* forms of imperfect competition, such as classic monopoly, would suggest that conventional measures of benefits are biased downward. But the discount rate may also be underestimated in such cases, which would introduce an opposing bias. Thus it is unclear whether internal scale economies cause conventional BCA to understate the economic worth of projects.

External scale economies operate among groups of producers, such as an industry, rather than within a single company. Since they are compatible with competition, they are better discussed in chapter 12, along with other 'positive externalities'.

IN SUMMARY

- Limits to competition in product markets cause errors in conventional transport BCAs. According to some common arguments, benefits are underestimated. But the same arguments would suggest underestimation of the discount rate, at least in the conventional approach to discounting. The overall direction of the errors, whether favouring or opposing the investment, is generally ambiguous.
- The measurement errors stemming from imperfect competition are hard to correct. Economists have had limited success in modelling imperfect competition.
- Measurement errors are likely to be small in many cases. Competition is strong in much of the Australian economy. For

⁴⁹ Under perfect competition, internal scale economies could shape some of the responses to transport improvements. But they would not constitute an 'issue' for BCA, since they would not undermine conventional measures of benefit such as the change in transport consumer surplus. See Mohring & Harwitz (1962, pp. 27–36) or Mohring & Williamson (1969, p. 257).

many transport BCAs, the loss of realism in assuming perfect competition may be worth the enormous saving in analytical effort. $^{\rm 50}$



⁵⁰ The paradigm of perfect competition has drawn varying assessments. A 'travesty of reality' is among the various scathing assessments, from noneconomists in particular (Ormerod 1994, p. 48). The consensus among economists is that the perfect competition paradigm 'can give useful insights into the workings of the economy' (Bannock, Baxter & Rees 1992, p. 338). Perfect competition is also a somewhat 'realistic description of world commodity markets where many traders deal in a homogeneous product' (Bannock, Baxter & Davis 1992, p. 326).
9

NATIONAL ECONOMIC MODELS: WHAT CAN THEY CONTRIBUTE?

National economic models are a minefield for the unwary analyst of transport projects. Their use can easily cause confusion, since they lie outside the conventional toolkit of transport BCA and can be difficult to understand. Applications of such models can also be expensive.

Sensible use requires forethought. One should carefully examine the potential of a model to assist with the key questions in a transport BCA:

- Does society stand to gain or lose, and what is the dollar value of the net gain or loss?
- How are the benefits and costs distributed among members of society?

ESTIMATING THE OVERALL GAIN TO SOCIETY Potential contribution: estimating transport outcomes

Transport BCAs usually focus on transport outcomes to measure benefits. A road BCA will measure cost savings for existing traffic and, sometimes, benefits from induced traffic (see chapter 2). For the other modes, examples of the transport-outcome focus are BTE (1975), BTCE (1996b), and the Port Phillip Region Airport and Airspace Study (1991).

National economic models can sometimes help to predict such transport outcomes. In particular, some traffic projections depend on forecasts of real GDP, which national economic models can provide.

For example, BTCE (1994b) took account of expected real GDP growth in predicting trade volumes through major Australian ports.



Some national economic models provide forecasts at the State level, which have also shaped predictions of port throughput (as in NIEIR 1992).

Even so, the task of traffic prediction will seldom call for customised applications of national economic models. If forecasts of the national economy are needed, ready-made ones, which are available at lower cost, will normally suffice.

Moreover, for most BCAs, a national economic model will be slight help at best in predicting transport outcomes. The outcomes will depend mainly on local factors that are absent from national economic models. For an example, see box 9.1.

BOX 9.1 TRAFFIC PROJECTIONS FOR THE BRINDABELLA ROAD

The Brindabella road crosses a mountain range to link Canberra and Tumut. In places, it consists of barely formed gravel.

BTCE (1997a) estimated the economic benefits of upgrading the road at the request of the Australian Capital Region Development Council. Information on the costs of upgrading the road was not available at the time.

The benefits would depend critically on the amount of traffic that the road would attract. Traffic projections were derived from a variety of data sources, including ABS projections of local populations. Industry and local government sources provided information on planned forestry developments in the Canberra–Tumut region, and on the implications for traffic on the Brindabella road.

National economic models played no role in the evaluation, and would not have made a significant contribution. They are generally too coarse geographically to help predict traffic at a very micro level.

Potential contribution: estimating outcomes throughout the economy

Transport investments have effects throughout the economy that are of interest in their own right. The implications for State and local economies and for government finances are often major concerns. People want to know how the investment will affect both themselves and others whose welfare interests them. They want to know the *distributional* effects.

But the distribution of costs and benefits is only one concern in transport BCA, and often a secondary one. Transport BCAs



concentrate on measuring the net benefit to society as a whole — that is, the total benefit minus the total cost.

The measurement of total benefit has sparked more debate than that of total cost.

To repeat: the standard measures of benefit are based on transport outcomes alone. These outcomes are hard to estimate because of uncertainty about future traffic levels, the value of travel time and other factors.

But there is also another common concern about the standard measures of benefit.

Some people believe that transport outcomes, even were they known, would be inadequate for measuring total benefits. In particular, it is often asserted that the measures based on transport outcomes will omit important benefits. Cox (1994, p. 82), for example, alleges the omission of 'flow-on' benefits that spread from transport to the rest of the economy. A remedy which he perceives is the use of national economic models to estimate the economy-wide effects of transport investments.

So the question arises for each transport BCA:

Does knowledge of the transport outcomes largely suffice for measuring total benefit?

If so, the measurement of total benefit will rarely call for a national economic model. As explained above, such models will generally throw little light on the transport outcomes. (The geographic detail is inadequate.) If, on the other hand, the measurement of total benefit requires information on outcomes economy-wide, national economic models could help, in theory. Such models could draw out the implications of transport outcomes for the rest of the economy.

Some studies have examined the adequacy of transport information using models of hypothetical economies (appendix II). The models used in such studies are highly stylised, abstracting from many realworld complexities. In particular, they lack dynamic structure.

A dynamic structure would recognise that a transport improvement can affect investment and savings, and that these effects have future consequences. For example, upgrading a rural road may induce local farmers to invest more in tractors and other machinery. The additional machinery will contribute to future output. The models of hypothetical economies being considered lack such dynamics, because they are 'comparative static' (glossary).



Such models, putting aside qualms about their lack of dynamics, offer a profound insight. They demonstrate that information on transport outcomes is largely adequate for measuring benefits under two conditions. In such models, sufficient conditions are:

- the economy is highly efficient; and
- total benefit is measured globally, without national or regional distinctions (that is, all benefits and costs count, no matter to whom they accrue).

Under these conditions, information beyond transport outcomes will only slightly improve the benefit estimate. Earlier chapters in this report set the stage for this conclusion. Chapter 2 shows how information on transport outcomes alone can capture the indirect benefits from a reduction in transport cost. Chapter 3 shows that such information also captures the transmitted benefits, provided that the economy is perfectly competitive and otherwise efficient. Both chapters are concerned with the total benefit to society without distinction.

Intuitively, an analogous conclusion should apply to the costs of transport projects. In a comparative static framework, there is little need to look at outcomes economy-wide, if the above conditions are met. The costs of construction to society are basically the costs incurred by the construction sector.

The efficiency condition lies at the heart of much debate about benefit measurement. To some Australians, their economy seems so inefficient as to render the above results as merely academic.

Among non-economists, this reaction stems partly from confusion about the meaning of 'economic efficiency' (glossary), and of the related notion of market failure. An economy may generate many outcomes that seem unfair, even cruel — such as pittance wages for some. Describing such outcomes as market failures has polemical appeal, and this contributes to the view that the economy is inefficient. In economics, however, the conventional definitions of these concepts exclude considerations of fairness. In this narrower sense, efficiency refers to the size of the 'economic pie' rather than to slicing it fairly.

Among economists, opinions about the efficiency of their nation's economy vary widely. A major bone of contention is the degree of competition, and how any shortage of competition affects the economy.



The other condition — that total benefit be measured without national or regional distinction — runs somewhat counter to BCA practice.

A nation's willingness to support a transport project normally depends on the benefits for its own people, not foreigners. The leakage of benefits to foreigners has been a big issue in some transport BCAs, especially of projects that will serve international traffic. Such analyses often exclude gains to foreigners from their measures of benefit. Examples include analyses of international airport facilities at Townsville (BTE 1976) and of European high-speed railways (Roy 1995).

The need to discount benefits to foreigners is thus a potential justification for using a national economic model.

Another justification for using national economic models, to which discussion now turns, is quite popular. It is also fairly shallow.

Partial versus general equilibrium analysis

Loose terminology has propped up many criticisms of conventional BCA assumptions. The misuse of 'market failure' to challenge the assumption of economic efficiency has already been mentioned.

Imprecise use of 'partial equilibrium' to characterise BCA has also confused matters. A transport BCA does not warrant this label simply because it focuses solely on transport 'outcomes in measuring benefits. Some analyses of this sort are more aptly called 'general equilibrium' because their assumptions are unrestrictive.

A partial equilibrium (PE) analysis artificially assumes certain things to be 'fixed' (strictly speaking, exogenous). All economic analysis resorts to this artifice, so the distinction between partial and general equilibrium (GE) analysis is one of degree rather than type (Kreps 1990, pp. 263–264).

Some models represent a nation's economy fairly comprehensively, and so earn the 'general equilibrium' label. But even they hold certain things fixed. For example, most applications of national economic models will ignore the effect of economic conditions on the nation's birth rate. The birth rate is exogenous in these analyses.

So rather than labelling a BCA as partial or general equilibrium, it is more useful to identify and assess the exogeneity assumptions. Many of the exogeneity assumptions in transport BCA will entail only a minor loss of realism. When all are fairly innocuous, the analysis is more 'general' than 'partial equilibrium.



Transport BCAs almost invariably treat as exogenous the prices of transport inputs. They conventionally value the savings in inputs at observed market prices, sometimes adjusted for taxes. For nonbusiness travel time, they take a proportion of some measure of hourly labour cost — the market price for labour. That the investment being evaluated could alter the market prices is only a minor hitch. Such price effects are generally negligible.

Example A: A road project might reduce the demand for tyres by smoothing the pavement (or in other ways). But even a major project would have minimal effect on total demand for tyres. If only for this reason, exogenising the price of tyres is warranted in a transport $BCA.^{51}$

The other main exogeneity assumptions in transport BCA concern traffic patterns. An investment in transport infrastructure has various effects on traffic patterns. It is common that a BCA does not estimate such an effect when it appears to be unimportant or when information is lacking.

Example B: An inland railway between Brisbane and Melbourne would attract traffic from other modes (BTCE 1996b). A preliminary analysis of the project allowed for a shift away from road transport alone. Air freight is generally too time-sensitive to make rail a feasible option. Diversion from sea transport, on the other hand, might warrant some attention in a comprehensive BCA of the railway. The omission of this effect from the preliminary analysis was due to constraints on time and other resources, together with a judgment that the shift from sea transport was likely to be small compared with a shift from road (chapter 4, notes). The omission may have caused some underestimation of benefits. (Shippers who change modes do so because they expect to benefit.)

It is also common for BCAs to exogenise some determinants of traffic patterns.

Example C: An inland railway between Brisbane and Melbourne would link grain producers in northern New South Wales with the Port of Brisbane. As a result, the railway would attract some grain traffic that currently goes to the Port of Newcastle. The preliminary analysis of the railway assumed port charges to be exogenous in estimating



⁵¹ To push the argument a little further, any effect on the price of tyres would dissipate over time. A fall in price would deter investment in tyre production, progressively reducing supply. The reduction in supply would, in turn, gradually moderate the fall in price. It is doubtful whether, in the long run, a significant decline in price would result from even a large reduction in demand.

total benefits. It also noted the contrary possibility that the Port of Newcastle might reduce charges to limit loss of business (BTCE 1996b, p. 19). In this event, the inland railway would carry less traffic than was estimated, which suggests a smaller benefit to society.⁵²

Many BCAs are vague about the assumptions behind their traffic forecasts. This makes it all the more difficult to classify them as 'partial' or 'general' equilibrium.

Example D: BTCE (1993) reviewed a BCA of a proposed railway between Darwin and Alice Springs. The traffic projections were key to the results of the BCA, which had been prepared by Australian National (AN). In arriving at its projections, did AN assume that the railway would generate an increase in total freight traffic? Or did it assume, in more partial equilibrium fashion, that the railway would simply draw traffic from other modes, with the total being unaffected? AN did not indicate in its report (BTCE 1993, p. 14).

A common furphy is that the partial equilibrium (PE) limitations of transport BCA cause underestimation of benefits. (The popularity of this view is also noted by Cox 1994, p. 81.) In truth, such limitations can cause either overestimation (example C) or underestimation (example B). Attempts to overcome the PE limitations will thus reduce the estimate of benefit in some instances, and increase it in others. For more on this point, see appendix II.

That the PE limitations of transport BCA generate much need for national economic models (Cox 1994, p. 81) is also largely a furphy. Although recourse to such models may allow relaxation of some exogeneity assumptions, the assumptions are often innocuous enough that the gain in realism is slight. For example, one might incorporate the effect of a road investment on tyre prices, but the effect would be minuscule for almost any investment (example A).

Even when exogeneity assumptions are arguably restrictive, national economic models will seldom offer much remedy. Chapter 5 recommends an exogenous treatment of aggregate employment because of the practical obstacles to doing otherwise, even with a

⁵² The same problem — failure to account for strategic price cuts by competitors — exists in some other BCAs. Sagner (1980, p. 361), for example, identified this problem in a BCA of the Tombigbee waterway in the US. The BCA did not account for the possibility that competing railways would reduce their freight charges to maintain market share. Sagner strongly implies that benefits were overestimated as a result. For more examples, see Mackie & Preston (1998, p. 3).

national economic model. In addition, the relaxation of many an exogeneity assumption would require more geographic detail than such models generally contain. To return to the above example of the port, predicting the strategic pricing responses at the Port of Newcastle would require local information of a kind normally absent from models of the Australian economy.

According to Cox, conventional BCAs measure benefits through PE analyses, which:

separate out a small section of the economy and analyse it through consumer surplus theory as if it were independent of other sections of the economy (Cox 1994, p. 81).

Granted, conventional transport BCAs focus on outcomes in the transport sector, which forms only part of the economy. However, BCAs do not treat the transport sector as independent of other sectors.

After all, why do savings in transport resources benefit society? Because the saved resources can now serve some other purpose. The truck driver made superfluous by a road improvement may end up working in another sector of the economy. A conventional road BCA will not ask which other sector that will be. But it does allow for the benefit from the driver's alternative employment (recall box 4.3).

Similarly, why does an improvement in transport induce additional traffic? Partly because of economic responses that occur outside the transport sector. An improvement that reduces freight costs for wheat may cause the wheat industry to expand. As production increases, so does the level of wheat traffic. BCAs that estimate an induced traffic benefit are actually estimating the benefit from the underlying responses — in this example, from the increase in wheat production. (See chapters 2 and 3.)

Transport BCAs abstract from *some* of the feedbacks between sectors of the economy. They are indeed partial equilibrium, to some extent. Whether the ignored feedbacks are likely to matter much is the pertinent question, and often they do not.

Evidence from national economic models

A number of studies have used models of the Australian economy to simulate the effects of transport investments. Most of the studies simulate the effects both during and after construction, costs as well as benefits. In contrast, the analyses of hypothetical economies that are discussed above (and in detail in appendix II) are much



narrower in scope. They focused on the benefits from a transport investment after construction.

The studies that have used models of the Australian economy have drawn on previously completed BCAs. The BCAs give estimates of construction and maintenance costs, and of transport outcomes such as the savings in travel time. These estimates are inputs to the simulations with national economic models.⁵³ The simulation outputs indicate the effects of the investment on real GDP, industry production levels, export volumes by commodity, and a host of other variables.

Most of the studies derive from their simulation results an estimate of the welfare gain to Australians. Typically, the measure of welfare is consumption-related. Brain (1997), for example, calculated the present discounted value (PDV) of forecast real consumption expenditure. Some studies exogenise public consumption expenditure (which covers items like education and health). The transport investment will affect only private consumption under this treatment. The other studies, including Brain's, endogenise public consumption expenditure, and simply add it to private consumption expenditure for welfare measurement. By implicit assumption, a dollar of consumption expenditure then confers the same benefit on society, be it public or private. (In reality, this equivalence may not hold, because public spending may be excessive for some consumption items and suboptimal for others.)

Comparisons between these estimates of welfare gain, which are simulation-based, and those from the BCAs, which supply inputs to the simulations, have sparked considerable debate.

The simulation-based estimates should, in principle, be more accurate because they take account of outcomes throughout the economy. The BCAs consider a more limited set of outcomes. To estimate benefits, they normally focus on transport outcomes. Similarly, most BCAs estimate the costs of construction and maintenance at market prices, sometimes adjusted for taxes. They do not estimate the economy-wide outcomes of the construction or maintenance activity.

⁵³ The interface between the BCAs and national economic models requires caution. One possible error is to double count benefits from induced traffic. For example, suppose that a road improvement draws freight traffic from railways. A simulation with a national economic model may indicate a benefit from this diversion, as may the BCA. None of the studies reviewed in this chapter have assured that they avoided double counting such benefits.

Some of the simulation-based estimates of welfare gain have differed substantially from the corresponding BCA estimates. This has fed claims that proper estimation of the welfare gains from transport projects will require a national economic model (see, in particular, Brain 1997, p. 76)

Other economists have been sceptical of such claims. BTCE (1995c) reviewed applications of the ORANI model to Australian transport investments. Account was also taken of other models of the Australian economy. The BTCE concluded:

In short, it is highly uncertain whether, in practice, national economic models can outperform conventional tools for measuring the net benefit of transport infrastructure investments (BTCE 1995c, p. 21).

Since that assessment, other studies have appeared that warrant review. These include studies of tariff reform (appendix II), where the issues in welfare measurement have parallels in transport BCA.

The City Link study

Allen Consulting et al. (1996) estimated the costs and benefits to Australian society of the Melbourne City Link project. The project provides a tollway through central Melbourne to link up with existing radial freeways. According to expectations, it will attract much of the through-traffic that currently congests central Melbourne (such as traffic between suburbs in the north-west and south-east).

The study of City Link starts by estimating the cost savings for existing traffic on Melbourne's roads, in what it calls a 'traditional' BCA. The costs considered were those of travel time, accidents and vehicle operation. The study also estimated the benefit from business traffic in Melbourne that the City Link would induce (see chapter 11 in this report).

The BCA provided data for simulations of the project's economywide effects. The effects during the construction and operation phases were simulated separately. The framework for analysis was MONASH MRF (abbreviated to MMRF), a general equilibrium model of the Australian economy split into States and Territories. The model is an extension of ORANI.

The measure of welfare gain was the PDV of the changes in real consumption expenditure (public and private) over the project's life. This was estimated at 1,107 million (valued at the prices expected for 2000–01).

For comparison, the welfare gain was also measured without the simulation results, simply using the 'traditional' BCA. This alternative measure was a PDV that summed construction and operation costs, the cost savings on existing traffic and the induced traffic benefit. The estimate of the PDV was \$1,246 million (again at prices in 2000–01).

The simulation-based estimate of welfare gain was thus about 11 per cent smaller than the BCA estimate.

The lack of dynamics in the MMRF model calls for caution in interpreting this comparison. In deriving their simulation-based estimate of welfare gain, Allen Consulting et al. made some adjustments for this omission (box 9.2). However, this cannot fully overcome the lack of dynamics.⁵⁴

Because of this and other uncertainties in the modelling, one cannot infer much from the direction of difference in the above comparison. One cannot infer that the BCA overestimated the welfare gain simply because the simulation-based estimate is 11 per cent smaller.

Allen Consulting et al. emphasise that the estimates are close, rather than one being smaller than the other.

'Our conclusion is that the net benefits of the City Link project are close to the present value of the net benefits calculated using traditional cost/benefit techniques' (Allen Consulting et al. 1996, p. 42).⁵⁵

This accords with the results from models of hypothetical economies. As discussed above, the results hinged on the assumed degree of efficiency.

The ORANI model and its derivatives (such as MMRF) assume a high degree of efficiency in the Australian economy. They assume perfect competition in product markets. Moreover, while nothing in the models denies a shortfall of employment, the applications under



⁵⁴ Horridge (1985) attempted to finesse the lack of dynamics in the ORANI model. He concedes that such fixes are inferior to the use of a dynamic model and that they are very hard for people to understand (M. Horridge, pers. comm., 29 September 1998).

⁵⁵ The study also notes that a project such as City Link can induce a substantial amount of other investment after completion. It continues: 'In this case, the overall economic benefits will be significantly larger than the direct benefits [estimated in the benefit-cost analysis]' (Allen Consulting et al. 1996, p. 19). However, the study made adjustments to account for the costs of induced investment (box 9.2). After the adjustments, there is no evidence that the City Link would have net benefits beyond the BCA estimates.

review, including the City Link study, have mostly exogenised aggregate employment. Transport investments will not affect aggregate employment, under the exogeneity assumption.

The MMRF model, like ORANI, nevertheless represents some inefficiencies that most transport BCAs omit. Examples are the inefficiencies arising from import tariffs and commodity taxes outside transport.⁵⁶ If only for this reason, the simulation-based estimate of welfare gain could differ somewhat from the BCA estimate.

Another reason for expecting some difference between the estimates is that they relate to different populations. The BCA estimate indicates the welfare gain from the City Link without regard to the distribution of the gain between Australia and other countries. The simulation-based estimate, on the other hand, indicates only the welfare gain to Australians as measured by their consumption level. In the simulations, the City Link affects foreigners by altering prices for Australian exports.

The Austroads study

Austroads (1997a) used the AE-CGE model to simulate the effects of road construction expenditures. It reported, as did the City Link study, little difference between the simulation-based estimate of welfare gain and the BCA estimate.

Measurement procedures can also explain some of the differences in measured rates of return. In the MMRF and ORANI databases, the returns to capital are based on estimates of gross operating surplus in the national accounts. The general government sector (excluding public enterprises) has a small gross operating surplus because of its non-commercial orientation. Thus for the ORANI industry 'public administration', the measured rate of return on capital is much below the economy average. For example, in the 1989–90 database, the figures are 3.5 per cent versus 12.7 per cent (gross of depreciation; Kenderes and Strzelecki 1995, pp. 30, 124–125). The traditionally non-commercial orientation of public administration, which accounts for this difference, says nothing about the efficiency of the Australian economy.



⁵⁶ The City Link study mentions, as another example of inefficiencies that MMRF captures, differences between industries in the rate of return on capital (Allen Consulting et al. 1996, p. 42.) In part, these differences might simply reflect risk factors. The MMRF database is a snapshot of the Australian economy in a particular year: 1990–91 at the time of the City Link study. Rates for return in some industries could have been below the economy's average in that year due to outcomes falling short of expectations. Then too, for industries with perennially high investment risks, the rate of return will typically exceed the economy average. This reflects a market premium for bearing risk rather than a difference in efficiency.

BOX 9.2 ADJUSTMENTS TO THE SIMULATION RESULTS IN THE CITY LINK STUDY

Allen Consulting et al. (1996) adjusted their simulation results for the costs of induced investments. Before adjustment, the simulations tell a partial story, as follows:

The City Link will reduce production costs for Australian industry, which will stimulate investment in Australia. The additional investment, once in place, will augment the productivity capacity of the economy. The resulting gain in national output will in turn cause national consumption to increase.

The simulations thus include benefits from the induced investment in the form of consumption gains. But they omit the costs of the induced investment, due to the lack of dynamics in MMRF.

To incorporate the costs, the estimated consumption gains during the operational phase were adjusted downwards. The estimated consumption losses during the construction phase were, on the other hand, adjusted upward: the simulations indicated that the City Link would crowd out other investment before it became operational (Allen Consulting et al. 1996, p. 40).

The inputs to the Austroads simulations were obtained from Allen Consulting (1993). The Allen study drew a sample of BCAs of recent road projects in Australia (122 projects). It then averaged the benefit-cost ratios (BCRs) by broad category of road (table 9.1). Local roads were thinly represented in the sample and were assigned a ratio based on less recent information.

The Allen study also derived typical percentage distributions of benefits. It divided benefits between savings in travel time, vehicle operating costs and accident costs. Further splits were between business and private traffic, and between industries (for business traffic). Austroads used the information from the Allen study to simulate, for each road category, an increase in construction expenditure of \$1 billion (at 1989–90 prices).

Comparing the BCRs implied by the simulation results with those from the benefit-cost analyses, Austroads concludes:

These results suggest that when the costs and benefits of road projects are modelled accurately, the differences between the partial equilibrium results of cost benefit analysis and the general equilibrium results using AE-CGE are relatively minor. It appears that any



economic benefits that flow on to the economy from road projects that are not captured in cost benefit analysis are relatively minor (Austroads 1997a, p. 96).

This sounds like the right conclusion. Austroads used a model of the Australian economy, AE-CGE, which resembles ORANI (see Austroads 1997a, pp. 147–156). So did the City Link study, which used MMRF (Allen Consulting et al. 1996). Further, both studies treated aggregate employment as exogenous. It would therefore be natural for Austroads to find, as did the City Link study, minor differences in estimates of welfare gains, moving from BCAs to national economic model simulations.

However, not all the differences between estimates of welfare gain are 'relatively minor' (table 9.1). For local roads, the BCR falls from 1.0 to 0.5, moving from the BCAs to the simulations. For rural arterial and national roads, there is also a downward jump of some significance.

This would seem to justify some explanation. Often enough, flaws in modelling emerge only after an explanation is attempted (box 9.3).

	Benefit-cost ratio from:	
Road group	Benefit-cost analyses	AE-CGE simulations
RURAL ROADS:		
National	2.1	1.5
Arterial	2.0	1.4
Local	1.0	0.5
URBAN ROADS:		
Freeways	4.8	5.4
Arterial	6.0	6.3
Local	1.0	0.5

TABLE 9.1BENEFIT-COST RATIOS FOR ROAD CONSTRUCTION:
AUSTROADS STUDY

Source Austroads (1997a, pp. 60, 96; tables 5.6 and 5.10). Austroads obtained the benefit-cost analysis results from Allen Consulting (1993); see text.

Note The sources did not attempt to validate the estimates from the benefit-cost analyses. However, errors in the BCA estimates would similarly affect the simulationbased estimates. Hence, they do not defeat the purpose of this table, which is to compare the estimates across columns. On the other hand, cross-row comparisons (between road categories) call for considerable caution (BTCE 1995b, p. 109).

BOX 9.3 THE IMPORTANCE OF EXPLAINING MODELLING RESULTS

Recent research on motor vehicle tariff cuts provides a case in point.

Dixon et al. (1997a) estimated that the tariff cuts would slightly benefit Australian society, based on simulations with the MONASH model. The study offered an explanation of the finding, but subsequent refinement of the explanation revealed an error. The error arose from the MONASH treatment of a miscellaneous category of production cost. For other cost categories, the model recognises corresponding inputs. For example, an industry's labour costs depend on its usage of labour. But for the miscellaneous category, which includes, for example, the costs of holding inventories, the model does not recognise corresponding inputs. As a result, the residual costs can produce spurious welfare effects in MONASH simulations (P. B. Dixon, pers. comm., 17 July 1998).

After correction of the error, the estimate of net benefit turned slightly *negative*, indicating that the tariff cuts would be bad for Australia (Dixon & Rimmer 1998). (In both studies, however, the authors caution that their assumptions are pessimistic.) The switch from positive to negative does not matter much, since both the earlier and revised estimates are quite small. Other errors in national economic modelling can be more consequential, and not all are discovered.

The comparative static limitations of the Austroads simulations are another concern. The simulations in the City Link study had the same limitations, but some adjustments were made (box 9.2). Austroads (1997a) made no adjustments. Granted, the task is difficult, and the adequacy of the adjustments in the City Link study is unclear. As already noted, adjusting the simulation results cannot fully overcome the lack of dynamics in a comparative static model.

Studies using the IMP model

Brain (1997) simulated the economic effects of an upgrading of the Princes Highway West, using models developed at the National Institute of Economic and Industry Research (NIEIR). The Institute's multi-purpose (IMP) model and its regional adjuncts were the principal models. Simulations were conducted under alternative assumptions about the balance of payments.

Brain concluded that the upgrading would benefit Australia far more than a 'conventional' BCA had indicated. His estimate of welfare



gain was about five times the BCA estimate in one simulation and about 13 times larger in another.⁵⁷

Large 'welfare multipliers' like these have not emerged from ORANItype analyses of road investments. As Brain observes, this is partly because of major differences between the models (Brain 1997, p. 75).

The IMP model credits the Australian economy with much less efficiency than do the ORANI-related frameworks discussed above. Competition promotes efficiency, and ORANI assumes competition in Australian industry to be perfect. The IMP model adopts alternative assumptions that are allegedly more realistic. Whether they are actually more realistic is arguable. What is certain is that they can produce quite different findings.

An example of the differences between IMP and ORANI-related models comes from studies of automotive tariffs. Brain (1992) used the IMP model to simulate reductions in automotive tariffs. The reductions had been proposed by the Industry Commission, which conducted its own simulations using the ORANI model (IC 1990).

Simulations from both models predicted that the tariff cuts would reduce demand for Australian-made vehicles. This much is obvious.

Contentious, however, was the effect on the price of Australianmade vehicles. The ORANI simulations indicated a negative effect, particularly in the short run (IC 1990, pp. 223–228). This would accord with many people's intuition: a fall in the demand for a commodity should lead to a drop in its price. As well, tariff reductions may sometimes galvanise domestic producers into lifting their efficiency to meet the heightened threat from foreign competition. The ORANI simulations did not include such efficiency gains, which would tend to reduce prices for Australian vehicles.

Interestingly, the simulations with the IMP model indicated the opposite. The price of Australian-made vehicles was predicted to increase due to the tariff cuts. The mechanism was something like



⁵⁷ The NIEIR appears to have produced similar findings in much earlier, possibly unpublished, research. Travers Morgan & RCA (1987, p. 6) drew on this research without providing publication details or any real description of the modelling. They went on to some 'indicative calculations' of their own, again not documented. They concluded that 'the estimates of ultimate benefits to the national economy from major urban road improvements should involve increasing the benefits conventionally calculated to the freight sector (for time and cost savings) by *about 50%*' (their emphasis). The Australian Automobile Association reported this conclusion in a recent submission to government (AAA 1997, p. 1357).

this: by reducing output in the Australian automotive industry, the tariff cuts would prevent the realisation of scale economies. The loss of scale economies would increase the unit cost of production, which would lead vehicle producers to raise their prices.⁵⁸

Because of such unorthodox predictions and features, the IMP model lies somewhat outside the current mainstream of Australian economics. In fact, Brain sometimes contrasts IMP model findings with what he acknowledges to be more conventional predictions from models such as ORANI and MONASH.⁵⁹ For further comparisons between IMP and other models, see James (1996) and Walker (1988).

The IMP model has a dynamic structure that yields forecasts for successive years. The effects of the Princes Highway upgrading, for example, were estimated for each year between 1997 and 2020. Such temporal detail was absent from the City Link and Austroads studies, which focused instead on 'typical years'. The dynamics in IMP model simulations can be complicated and sometimes difficult to understand (box 9.4).

Unfortunately it is very difficult to evaluate the IMP model, because complete and current documentation is unavailable to the public. It is less transparent than some other models, such as ORANI and MONASH. Brain (1986) set out the IMP model in some detail, but there have been significant changes since then. James (1996, p. 37) makes the same observations about the documentation for the IMP model, while adding that the 1986 version still captures the model's basic features. However, the 1986 documentation did not fully explain the theory for its equations (box 9.5).

- 58 There are some flaws to this argument. In the IMP model, the scale economies in the automotive industry depend on total industry output. In reality, they also depend on the output at the level of the company, plant and vehicle model. At this more micro level, a tariff cut can foster scale economies. Suppose, for example, that a tariff cut causes some manufacturers in the industry to close. Some of the manufacturers' business would go to the remaining Australian producers. Output among the remaining producers might increase, despite total industry output declining. Scale economies might improve in this situation, leading to a reduction in unit cost. Moreover, even if a tariff cut were to increase unit cost, it does not follow that producers would raise prices. For further discussion, see IC (1990, pp. 235–239).
- 59 See, for example, Brain (1997, p. 75). MONASH and ORANI are computable general equilibrium (CGE) models, whereas the IMP model is of a kind sometimes described as 'macro-econometric'. The distinction between these categories is blurred and often exaggerated. A frequent mistake is to ascribe to all CGE models certain common features, such as the assumption of perfect competition (for example, Austroads 1997a, p. 102).

BOX 9.4 THE IMP MODEL: DYNAMICS

The complex dynamics in the IMP model are exemplified by NIEIR (1985). The study estimated the effects of the post-1968 changes in consumption patterns on the industry distribution of employment. It used the IMP model to forecast industry employment shares from 1987 to 1990.

In the 'control' forecasts, the consumption patterns were those expected to prevail during that period. In the 'disturbed' forecasts, the consumption patterns of 1968 were superimposed. The difference between the forecasts thus indicated the effects on industry employment shares of the post-1968 changes in consumption patterns.

For some industry categories, the findings were highly unstable within the forecast period. One such industry was that producing transport equipment. The post-1968 changes in consumption patterns were projected to reduce its employment share by 20 per cent in 1989. Curiously, the projected effect for 1990 was an *increase* in employment share of 16 per cent. The NIEIR did not explain this instability. For more discussion of the study, see BLMR (1987, pp. 233–235).



What of the idea that a national economic model, even if a bit arcane, can stand on its forecasting record?

For evaluating transport investments (and other 'micro' developments), the idea is naive. To see this, consider the employment effects from upgrading the Princes Highway West, as estimated in Brain (1997, p. 109). For the first year after the project's completion, assumed to be 2007, the estimate is for an additional 1 200 Australians to be employed. If the IMP model had a record of forecasting aggregate employment 10 years ahead within a margin well under 1 200, one might trust this estimate implicitly. But such accuracy would far exceed the ability of any national economic model. After all, the estimated gain in employment in 1996–97 — to be more precise, 0.014 per cent (ABS 1998c, p. 184) — and would amount to an even smaller proportion in 2007. More generally, the estimated effects of transport investments are

small relative to the forecasting errors that can be expected of national economic models. 60

To improve the level of confidence in the findings in Brain (1997) would require, for a start, access to full and transparent documentation of the IMP model. The study itself provides only some information on the model⁶¹.

BOX 9.5 THE IMP MODEL: DOCUMENTATION

The Industry Commission inquiry into automotive tariffs examined the documentation of the IMP model in Brain (1986). It paid particular attention to the equations for output prices in Australian manufacturing (IC 1990, p. 236). (An analysis prepared with the IMP model had yielded the surprising prediction that reducing automotive tariffs would increase prices for Australian-made vehicles; see text.)

In the equation for the motor vehicle industry, the output price depends negatively on the industry's degree of capacity utilisation. The documentation indicates that the equation is anchored in a theory of imperfect competition, but the theory is not made clear. (It is hard to see capacity utilisation as a causal variable; both it and output prices are determined by other factors such as demand conditions.)

Moreover, the negative direction of the relationship is anomalous. In each of the other 26 manufacturing industries for which the IMP model includes such a relationship, the direction is positive: an increase in capacity utilisation positively influences the output price. The documentation gives no reasons for this anomaly. For many industries, including motor vehicles, the estimate of the capacity utilisation effect is statistically significant.

⁶⁰ More information is needed on the forecasting performance of models of the Australian economy. Some studies do not report the forecasts they prepare. Among these are several recent applications of the IMP model to transport policy (NIEIR 1995a, 1995b, 1998; Brain 1997). None reported the forecast values. They reported only the *differences* between alternative forecast values for the scenarios with and without the transport initiative being evaluated. These differences are the estimated effects of the initiative. So, for example, the applications report the estimated effect of the initiative on real consumption, but not the forecast level of real consumption in either scenario. This precludes a retrospective check on the accuracy of the forecasts, unless the forecasts can be obtained from some other source.

⁶¹ Full and transparent documentation of the IMP model would not obviate the need for fuller discussion in the study. The secrets of a model are often in the details, and poring over the details can be arduous. Studies that use national economic models should spare the reader much of the trouble. They should provide a largely self-sufficient explanation of their findings, highlighting those aspects of the model that are particularly relevant. A good example is Dixon and Rimmer (1998).

Brain explains the large welfare multipliers as follows:

Induced investment. Brain (1997, pp. 90, 101) argues that the improvement to the highway network, once in place, will stimulate other investment. In line with one strand of the economic literature on investment (see Hubbard 1998), the IMP model recognises that firms may be constrained in their investment effort by the availability of internal funding. The highway improvement increases the internal cash flow by reducing the cost of production. Investment increases as a result. This occurs particularly in industries where world markets set output prices. Other industries pass on their cost reductions to their customers through lower prices.

Missing from this story are rates of return on investment. In some other national economic models, such as MONASH, rates of return are key determinants of investment levels. On the other hand, MONASH does not impose an internal funding constraint on investment levels.

As this illustrates, the modelling of investment decisions differs fundamentally across models of the Australian economy. Partly because of this, the models can give quite different results for the same economic 'shock'. Hargreaves (1994) compared results from simulations of a uniform 5 per cent improvement in labour productivity. He found the results to vary dramatically between models for the short and medium run, and the modelling of investment to be critical.

The investment paradigms vary so much across models because of many unresolved issues. For example, investment decisions depend on expectations of future returns, and economists have difficulty agreeing on how investors form their expectations. Hargreaves describes the modelling of investment decisions as one of the weakest areas of economics. He also quotes John Freebairn as likening it to a 'graveyard for economists and econometricians' (Hargreaves 1994, pp. ix, 30).

The controversy about the modelling of investment underscores the need for transparency. To fully evaluate a model's treatment of investment requires complete access to the mathematical specifications, the supporting evidence and the underlying theory. Enough information to replicate the analysis and to perform sensitivity tests would also be needed.

For modelling any particular investment, a full discussion of the displacement issue is essential for transparency. Brain (1997) acknowledges that the costs of *private* infrastructure investments can



displace other investments. This is consistent with the liquidity constraints on private investment in the IMP model. With reliance on internal funding, a firm that invests more in one area will have to cut back elsewhere.

However, Brain dismisses such displacement as a likelihood for publicly funded investments. Indeed, a look at the simulation results for the Princes Highway West project reveals almost no displacement of other investment.⁶²

It is not clear why this should be. The financing requirements for public investments can displace other investments. Governments may fund a transport infrastructure project by cutting other capital expenditure. Increases in taxes could also displace some private investments, as could other means of financing (see chapter 5).

Increase in capacity utilisation. Brain (1997, p. 101) argues that in the IMP model, firms may be operating at suboptimal capacity utilisation, depending on general economic conditions. In the simulation of the Princes Highway upgrading, capacity utilisation increases.

It is not clear why capacity utilisation would be suboptimal in the Australian economy. Capacity utilisation will be lower than was planned in some cases, but this does not mean that it is suboptimal. If demand were to unexpectedly plummet for, say, mineral exports, substantial idle capacity in mining could be optimal under the circumstances. A low degree of capacity utilisation in some sectors is thus consistent with an efficient economy.

Perhaps the IMP model features suboptimal capacity utilisation because of other inefficiencies that it assumes (such as imperfect competition). If so, an explanation is needed.

62 The estimated construction costs are similar to the estimated increases in aggregate real investment (Brain 1997; compare p. 91 with p. 129). The estimated increases in aggregate real investment are, in fact, slightly higher. In other words, the estimates indicate that the highway construction costs would stimulate additional investment, rather than displacing it.



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Employment gains are also mentioned (Brain (1997, pp. 75, 91). The simulation results indicate that the upgrading of the Princes Highway would increase aggregate employment. Both the construction activity and the resulting highway improvements are estimated to have this effect. The increase in employment boosts national output, leading to an increase in consumption levels. This accounts for much of the net benefit attributed to the upgrade.⁶³

The inclusion of employment gains runs counter to the recommendations in this report. Chapter 5 recommends an exogenous treatment of aggregate employment in evaluations of transport investments. The grounds for this position are practical. Reliable estimation of the aggregate employment effects of transport investments appears to lie beyond the current capability of economics. To comment on the estimation of employment gains in Brain (1997) would require additional information on the current version of the IMP model.

Moreover, an increase in aggregate employment, were it to result from the highway upgrade, would entail some cost to society. In addition to the loss of time for non-work pursuits, there are workrelated costs such as commuting and child care. On the basis of the information available, the application of the IMP model to the Princes Highway appears to have ignored the costs of employment, while estimating the benefits.

Future applications of national economic models

In past applications, models of the Australian economy have revealed little about the net benefits of transport investments. Some have



⁶³ So it would appear from 'back of the envelope' calculations. For the year 2007, immediately after the completion of construction, Brain estimates that the highway improvement would increase national output (real GDP) by \$57.7 million at 1990 prices. As was noted above, the estimated employment gain for that year is 1,200 workers. At an average compensation per worker of \$30,000 annually, the gain in employment would mean an increase of \$36 million in the returns to labour. This amounts to about two-thirds of the estimated increase in national output. (GDP can be expressed as the returns to labour and other factors of production plus indirect taxes.) The average compensation per worker of \$30,000 compares with \$29,730 from the ORANI database for 1989–90 (Kenderes and Strzelecki 1995).

basically reaffirmed the estimates from transport BCAs.⁶⁴ Those that have produced quite different estimates have provided insufficient explanation or documentation to be convincing. Time will tell whether future applications will reveal more.

In theory, models of the Australian economy can capture some welfare effects that transport BCAs treat inadequately. Such models can differentiate between the welfare of Australians and foreigners, whereas many BCAs estimate the net benefit without national distinction. The models can also capture some welfare effects that arise from the interaction between transport and inefficiencies in the larger economy.

Nevertheless, the prospects for future applications of national economic models to remedy the omissions from BCAs are limited. The omissions have several characteristics that suggest this assessment:

Some of the omissions from BCAs are relatively inconsequential. In this category are the omissions connected with commodity taxes outside transport (chapter 7). In Australia, commodities that are highly taxed, like alcoholic beverages, are the exceptions. Fuel is another, but transport BCAs take account of this. Moreover, the recent enactment of a comprehensive goods and services tax (GST) will make it easier for BCAs to allow for commodity taxes (chapter 7).

⁶⁴ Cox (1997) perceives a problem with reported comparisons between conventional BCAs and general equilibrium analyses (which use national economic models).

^{&#}x27;The present value of GDP benefits obtained from modelling the construction and operation phase [of road projects] and excluding the induced investment effects has been compared with consumer welfare benefits calculated in normal benefit-cost analyses. These show a reasonable agreement, but it should be noted that no allowance for the benefits to private [non-business] travel from major road projects are included in the general equilibrium analyses. Some positive externalities from road transport ... are therefore ... evident from this general equilibrium modelling work' (p. 145).

The BTE is unaware of studies that fit the above description and it is unclear exactly which studies Cox has in mind. True, some studies of road investments have reported comparisons of BCA and general equilibrium estimates of welfare gain in which the numbers turn out to be similar. However, none of the comparisons known to the BTE suffer the lack of comparability that Cox describes. For example, the comparison in the City Link study excluded the benefits to non-business travel from *both* estimates (Allen Consulting et al. 1994).

Omissions connected with imperfect competition in product markets are also of questionable significance. Competition in much of the Australian economy appears fairly keen.

Some of the omissions cannot be readily rectified. Economists have had limited success in modelling imperfect competition in product markets (chapter 8). Inefficiencies in labour markets are still more of a challenge (chapter 5). For modellers venturing into these areas, some sensitivity analysis would be prudent.

The division of welfare gains between Australians and foreigners is theoretically more tractable, but dependent on parameters that are hard to estimate. Each model of the Australian economy has parameters that determine values for export demand elasticities. For the major export commodities, most of the values in ORANI are very high (Dixon, Parmenter, Sutton, & Vincent 1982, p. 196). For example, the elasticity for coal exports implies a decrease in demand of about 20 per cent for a 1 per cent increase in price. Cronin (1984) argues that lower values would be more realistic, and lower values have featured in the IMP model (Walker 1988, p. 7). Since the issue is unsettled, sensitivity analysis is again advisable.

The division of welfare gains also depends on effects in asset markets. For example, an investment in Australian infrastructure, in theory could affect Australian interest rates. If the interest rates increase, some of the welfare gains accrue to foreign lenders. The interest rate effects depend partly on how the investment affects the current account balance.⁶⁵ As explained below, the effects on the current account balance are an estimation quagmire.

Moreover, an investment in infrastructure can affect interest rates through other channels. For example, a good investment could increase foreign confidence in the Australian economy, reducing the risk premium on Australian borrowings. (Corden makes much the same point in his incisive analysis of the current account deficit; Corden 1991, p. 9.) So the overall effect on interest rates could be negative, even were the current account balance to worsen. Mexican experience illustrates this sort of scenario. Economic reforms in the early 1990s improved confidence in the economy, contributing to a massive inflow of foreign capital. The flip side of this inflow was an accompanying increase in the current account deficit. At the same time, the yield on five-year Mexican Government bonds fell from 8 percentage points above comparable American Treasury bonds to less than one-and-a-half points in late 1993 (The Economist, 7 October 1995, p. 18. of the World Economic Survey).



⁶⁵ Say that an infrastructure investment pushes the current account balance toward deficit. That would increase the stock of external debt. And to induce foreigners to hold the additional debt, Australia must offer higher interest rates - so the story goes. But there has been much disagreement as to the strength of this relationship.

The biases from the omissions can be positive or negative. Some omissions from transport BCA will cause an understatement of benefit, others an overstatement. With many omissions hard to rectify, it can be very difficult to judge the overall direction of bias. After sensitivity analysis, simulations with national economic models will provide a range of estimates of net benefit. If the sensitivity analysis is adequate, the BCA estimate will often fall well within this range. The result is a bland conclusion: the BCA estimate could be either too high or too low, depending on factors that are beyond the modeller's knowledge.

Declines in export prices illustrate the potential for BCAs to exaggerate benefits. An improvement in transport infrastructure can reduce production costs in Australian export industries. In an industry where producers compete vigorously, the cost reduction will stimulate an increase in supply, driving prices down. Prices would fall for foreigners as well as for domestic customers. The decline in the price that foreigners pay would be a loss to Australia. But few road BCAs estimate such effects. This omission can impart a negative bias to the estimate of net benefit.

Positive biases could arise from other omissions. For example, according to some common arguments, transport BCAs understate benefits by ignoring imperfect competition in product markets (chapter 8).

If models of the Australian economy can help estimate the welfare gains from transport investments, their contribution is likely to be limited to special cases. Such cases might include investments in Australian seaports, for example. The division of welfare gains between Australians and foreigners has particular relevance to seaports. Although the division would be hard to pin down, a national economic model may sometimes help. However, for some time to come, there may not be many investments in seaports that warrant a large-scale evaluation. Most Australian seaports had under-utilised berth capacity in 1994, sufficient to meet expected demand over the next 20 years (BTCE 1995b, p. 79).

ESTIMATING MACROECONOMIC EFFECTS

With inflation apparently under control for now, other macroeconomic indicators dominate discussions of Australia's economic health. Among the most popular are real GDP, the current account balance and the unemployment rate. When people argue that a transport

project serves the national interest, they often want estimates of the effects on these or related indicators. 66

But this is a poor justification for using national economic models.

If such models cannot yield reliable estimates of the effects on aggregate employment, as was argued in chapter 5, neither can they reveal the effects on the unemployment rate. For evaluation of transport projects, the most practical assumption is that such effects will be absent.

For the other popular macroeconomic indicators, there are major problems in estimation, or interpretation, or both.

The current account balance

Investments in transport infrastructure can have quite different effects on the current account balance depending on the stage of the project.

Effects during construction

During the construction period, the investments are likely to reduce the trade balance, pushing the current account toward deficit. (The trade balance forms part of the current account balance; see glossary.)

The decline in the trade balance frees up resources for construction. A fall in export production releases labour and other resources that can be used for construction of a transport project, either directly or in industries that supply inputs (like steel for railways). An increase in imports can also supply the needed resources.

Another resource-freeing mechanism is restraint in domestic spending. During construction, a transport project may displace spending on other investment or on consumption.



⁶⁶ The Road Transport Forum (RTF), for example, commissioned a study based on the ORANI model. Simulations were reported for an additional \$12 billion investment in Australian roads (a once-off increase). To convey the long-term benefits, the study highlighted the estimated effects on three macroeconomic indicators: real GDP, aggregate employment, and total exports (Swan Consultants 1994, p. iii). The RTF, in its media release on the study, emphasised the effect on total exports, calculating that it would be sufficient to eliminate the current account deficit within seven years (RTF 1995). The calculation is incorrect, however, because exports form only part of the current account balance. For more explanation of the error, see BTCE (1995, pp. 19–20). Another discussion of transport investments that emphasises the current account deficit is FitzGerald (1995, p. 30).

All these mechanisms are likely to operate during construction of a transport project: displacement of investment, consumption restraint and a fall in the trade balance. Greater reliance on any one mechanism reduces the need for the others.

However, the relative reliance on the different mechanisms is difficult to predict.

Some studies have dealt with this ambiguity through scenario testing. CREA (1990) used the ORANI model to analyse the VFT, a project for a high-speed rail service between Sydney and Melbourne. By assumption, the project's resource requirements reduced the trade balance in one scenario, and displaced consumption spending in others.

Austroads (1997a) specified similar scenarios for simulating road investments. One was a reduction in the trade balance, the same as in the VFT study. The other was displacement of consumption and investment spending in a model-determined proportion. The model indicated that consumption 'bears the brunt' of displacement (Austroads 1997a, p. 80). Maybe, but alternatively, a government might fund some road investment by reducing its other investment expenditure. The Austroads modelling of investment does not admit this possibility.

The City Link study (Allen Consulting et al. 1996) used assumptions in place of scenario testing. The assumptions ensured that a reduction in the trade balance would be the main resource-freeing mechanism in the construction-phase simulation. Such a reduction in the trade balance implies that foreigners are effectively funding the City Link project. The estimated effects of the project on real domestic spending — consumption and investment — were slight.

Matthew Peter, who performed the City Link simulations, considers this the most realistic pattern for the City Link and other private investments in Australia (M.W. Peter, pers. comm., 25 August 1998). He believes that capital is highly mobile between Australia and other countries: that the expected return on investments in Australia would have to increase only slightly to attract additional foreign investment.

But the degree of international mobility of capital is a matter for debate. Evidence that forms the 'international diversification puzzle', while inconclusive, suggests that mobility may be far from perfect. Baxter & Jermann (1997) examined investment patterns in four major economies: Japan, Germany, the US, and the UK. They calculated that, if capital were perfectly mobile, it would pay investors in each country to invest much of their wealth abroad. In reality,

however, international diversification is far more limited. For example, US investors hold about 94 per cent of their financial assets in the form of US securities (French & Poterba 1991, as cited by Baxter & Jermann 1997, p. 170).

Moreover, even if capital were highly mobile between Australia and abroad, adverse pressures on the trade balance could provoke countermeasures by the Federal Government. The government might reduce public spending or raise taxes, either of which would curb domestic consumption or investment spending. The drop in domestic spending in turn would move the trade balance back toward surplus. (It would reduce demand for imports and release resources for export production.) The City Link might produce these countermeasures even during its construction, originally expected to take four years.

Effects after construction

After construction, a transport project could affect the current account balance either positively or negatively, and the direction of effect can vary over time. Again, estimation of the effect is quite difficult.

One influence will be the after-effects of construction costs. These will depend on the mix of resource-freeing mechanisms that operated during the construction phase. For illustration, suppose that all the resources for the project came from a reduction in the trade balance. This would have led to a simultaneous reduction in the current account balance (a move toward deficit).

In simplified terms, the move toward deficit would have entailed borrowing from abroad. For the increase in foreign debt to be subsequently eliminated, the current account balance must eventually move toward surplus. An increase in the trade balance would be the mechanism; and several studies have assumed such an increase to occur in operating phase scenarios (Allen Consulting et al. 1996; Austroads 1997a; CREA 1990).⁶⁷ But the moves toward surplus,



⁶⁷ These studies assume that the trade balance would increase by exactly enough to eliminate the additional foreign debt. However, this assumption is speculative. Alternatively, the increase in the trade balance might reduce the foreign debt without ever eliminating it. For example, if the trade balance moved toward surplus by just enough to service the interest on the debt, the principal would remain intact, a negative inheritance for Australians. In the current account, the continuing interest payments would be a debit entry, while the increase in the trade balance would be a credit. The debit and credit would be exactly offsetting, so the current account balance would be unaffected.

were they to occur, would merely represent deferred costs of the project. To interpret them as indications of benefits would be entirely specious.

Other effects on the current account balance can arise from the enhancements to the transport network.

To focus on these effects, consider a hypothetical improvement in Australian transport that entails no costs to Australian society. (A foreign aid project or, about as likely, a gift from heaven.) The improvement raises productivity in the entire transport sector. The required amounts of inputs, such as labour and fuel, decline for any given transport task.

One could simulate this scenario — an across-the-board improvement in transport productivity — using various models of the Australian economy. But dependable conclusions about the effect on the current account balance, even about direction, would be unlikely to emerge.

A previous attempt at something like this justifies the pessimism. Hargreaves (1994) compared simulation results from six models of the Australian economy. The scenario in each simulation equated to a 5 per cent increase in aggregate labour productivity. The increase varied around this figure by industry, and was assumed to occur gradually over five years.

The estimated effects on the current account balance differed significantly between models. Ten years into the scenario, the G-cubed model indicated a decrease in the current account balance equal to almost 2 per cent of baseline GDP. ('Baseline' refers to the value that would prevail in the absence of the productivity improvements.) At the other end, the TRYM model indicated a move toward surplus of 0.4 per cent of baseline GDP.

For some of the models, the estimated effect on the current account balance varied between positive and negative over the simulation period. The TRYM model exhibited the most complex pattern, moving from positive, briefly to negative, then back to positive. The stock of foreign debt may thus be more informative, to the extent that it accumulates changes in the current account balance. But the crossmodel variation remains substantial even after this change in focus.

Why are there such difficulties in estimating the effects on the current account balance?

A national accounting identity helps to understand this. The current account balance equals aggregate investment minus aggregate saving. (For this and other ways of viewing the current account

balance, see *The Economist*, 30 August 1997, pp. 19–20, or Dornbusch & Fischer 1990, chapter 6). A gain in productivity would increase both investment and saving, but economists have trouble modelling either. The unresolved problems in modelling investment decisions were mentioned earlier in this chapter. Much remains to be understood about saving decisions as well (box 9.6).

In simulations, an improvement in transport productivity can move the current account balance toward either deficit or surplus, depending on how investment and saving decisions are modelled.

The effect on the current account balance reveals little about the worthiness of a transport investment. An ideal investment would increase transport productivity at zero cost to society. But this godsend would not necessarily reduce the current account deficit or

BOX 9.6 WHAT DRIVES NATIONAL SAVING: GAPS IN KNOWLEDGE

A recent review of the literature on household saving decisions identified some large gaps in economists' knowledge (Browning & Lusardi 1996). For example, it found that economists 'are still some way from having a convincing explanation of the saving decline' that has occurred in the United States, particularly since the mid-1980s. (For the debate in a nutshell, see *The Economist*, 30 August 1997, pp. 19–20.) The magnitude of this decline would certainly call for an explanation. American households saved an average of 8.2 per cent of their disposable income from 1970 to 1974; by the late 1980s, this had fallen to well under 5 per cent, according to revised official statistics (Browning & Lusardi 1996, pp. 1817, 1825).

Likewise, economists are still some way from reliable estimates of how tax reforms affect household saving. Treasury secretary Ted Evans has argued that tax reform is essential to boost Australia's level of saving and to help narrow the current account deficit. He also acknowledged that, in theory, shifting the tax burden toward indirect taxes [rather than income taxes] should stimulate saving (*The Australian*, 19 May 1998, p. 4). 'But he added: "You won't find that convincingly [demonstrated] in studies" of international tax reform experience'.

Aggregate saving also depends on another hard-to-model factor: the level of public consumption expenditure. (Aggregate saving equals national income minus aggregate consumption.) Studies of transport investments in Australia have dealt with this modelling problem through arbitrary assumptions. For example, the study of the City Link assumed that the project would affect public consumption expenditure in the same proportion as private consumption expenditure (Allen Consulting et al. 1996, p. 23). In contrast, the VFT study assumed no effect on real public consumption expenditure in some of its simulations (CREA 1990, p. 2).



external debt. Modellers who estimate such effects may be reporting what their clients want to hear. The effects could go in the other direction.

Real Gross Domestic Product (GDP)

The problems with the current account balance also apply, in lesser degree, to real GDP. The effect on real GDP is a flawed measure of the benefit from a transport investment. It is also quite difficult to estimate.

Effects during construction

Some studies of transport projects have estimated large gains in real GDP from the construction activity. These gains are large relative to the amount of construction expenditure. For example, work to upgrade the Princes Highway West would boost real GDP by \$7.9 million during the first year, against an expenditure of \$15 million, on the estimates in Brain (1997, pp. 91, 129). Relativities of this sort have also appeared in other Australian studies, among them BTCE (1996c, p. 20) and, in their sensitivity analysis, Allen Consulting et al. (1996). An overseas example is a study edited by Roy (1996, p. 17).

In these studies' simulations, the construction activity for the project boosts aggregate employment, which contributes to the gains in real GDP; however, the estimates of employment gains are very speculative.

Effects after construction

Estimates of real GDP gains after construction are also speculative. Clouding the picture are the problems in modelling investment, the so-called 'graveyard' for economists. The resource requirements for a transport project can displace other investments, while the fruits of the project, such as better roads, can induce complementary investments. The changes in investment, in turn, would affect real GDP.⁶⁸ With investment decisions being so hard to model, the estimates of real GDP effects can vary significantly.

⁶⁸ Transport projects can affect investment in both human and physical capital. As a rule, national economic models will omit the effects on human capital. Suppose, for example, that a government funds a transport project by reducing expenditure on education. The cutbacks to education would make for a less productive workforce in the future, reducing real GDP. The BTE does not know of any model of the Australian economy that would be suitable for simulating transport investments and that would capture such effects on real GDP.

The investment responses to a transport project, besides making the project's effects on real GDP hard to estimate, also argue against focusing on these effects. Once again, consider a road project that lowers freight costs for a farm industry; to keep the example uncluttered, this is the only benefit.

The project would reduce the amounts of labour and other resources that a given farm freight task requires. The freed resources would then contribute to production in the economy, boosting real GDP.

The reduction in freight costs might also induce the farmers to invest more in machinery. The induced investment would lead to further gains in real GDP. The additional machinery would bolster farm production, so increasing national output.

The costs of the induced investment, on the other hand, would not show up in real GDP. Suppose that the investment occurs in the year 2000, and that farmers find the money by spending less in that year on consumption — postponing the new washing machine, the holiday to Cairns, whatever. The re-allocation of their expenditures would change the composition of national output in 2000. But it would not necessarily increase or decrease that year's level of national output.

The gains in real GDP would therefore tend to overstate the benefit from the freight cost reduction. They would reflect the benefits from induced investment but not the costs.

Gains in aggregate employment would compound the problem. If a transport project were to produce such gains, the additional employment would increase real GDP. But the costs of the additional employment, such as loss of time for relaxation, would not show up in real GDP (or they would have effects on real GDP that national economic models do not measure).

A multi-criteria analysis?

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How about a multi-criteria analysis (MCA) of transport projects, with macroeconomic criteria included? Real GDP, the current account balance and other indicators convey a useful picture in combination, though each is inadequate on its own — such an argument would doubtless appeal to some MCA proponents.

Such an analysis would, however, simply marshal a hodgepodge of macroeconomic indicators, and either weight them arbitrarily or leave others to make sense of them. For more detailed discussion of multi-criteria analysis, see chapter 13.

ESTIMATING DISTRIBUTIONAL EFFECTS

People often want to know how a transport project will affect State and regional economies. Another common question is how the project will affect government finances, taking all influences into account.

Some studies have used models of the Australian economy to estimate these and other distributional effects.

What is uncertain is whether such estimates are sufficiently informative to justify the modelling costs. How well will the estimates stand up to scrutiny? Are there other frameworks, apart from national economic models, that can accomplish much the same but at lower cost? For each intended application of a model, these questions must be weighed carefully.

State and regional effects

Effects of resource requirements

One of the obstacles to estimating State and regional effects should now be familiar. To free up a supply of labour and other resources for a transport project, something else in the economy must 'give'. Spending on other investment or on consumption must decline, or the trade balance must move toward deficit. The mix of these resource-freeing mechanisms will shape the State and regional effects. The mix is also highly uncertain for many transport projects.

Sensitivity analysis is the poor man's way around the obstacle. To cover the range of uncertainty, such analysis must include diverse scenarios about resource supply. The estimated effects on State and regional economies will often be scenario-sensitive, leaving an unclear impression.

An example of this murkiness emerged from the study of the Very Fast Train project (CREA 1990). The analysis consistently indicated that the construction activity would stimulate the economies of Victoria and New South Wales (where the activity would occur). For the other States, the estimated effects of construction activity were scenario-sensitive. When the resource-freeing mechanism was assumed to be a decline in net exports (the trade balance), the States most adversely affected were Queensland and Western Australia. This reflects the strong export orientation of these States' economies. In the scenario where the VFT displaced consumption rather than net exports, Queensland and Western Australia fared no worse than the other non-VFT States. CREA did not indicate which scenario was the more realistic.

Effects of better transport

Transport projects also affect State and regional economies by improving the transport system. Several Australian studies have estimated such effects within models of the national economy.

There are two approaches to representing State/regional economies within national economic models.

The 'top down' approach takes the location distribution as given for most of mining, agriculture and manufacturing (box 9.7). For this reason, it has quite limited value for analysing transport investments. More suitable uses have included the estimation of State-level effects of tariff reform (as in Dixon et al. 1997a).

The 'bottom up' approach promises a much fuller picture of how transport improvements affect State/regional economies. The problem is implementation. Data requirements are far greater than for the top down approach.

For a start, one needs input-output (I0) tables indicating the trade flows between States. In Australia, the Australian Bureau of Statistics (ABS) does not compile subnational IO tables, leaving the task to others. Data being costly to collect, the creators of such tables often synthesise entries, combining limited evidence with reasoned conjecture.⁶⁹ Jensen, West & Bayne (1993) describe this sort of approach; see also Beemiller (1990) and Bolton (1985).

The bottom up approach also requires parameter estimates for the location choice equations. With data on geographic trade flows scarce, this is a tall order.

For the IMP model, available documentation reveals little about the estimation of location choice parameters (NIEIR 1995b).

The other 'bottom up' models of the Australian economy are MMRF and the STATE model (Peter et al. 1996; Swan Consultants 1996). MMRF was used to analyse two transport projects in Melbourne: the City Link and a ring road (Allen Consulting et al. 1996; FDF Management 1995). The STATE model and its predecessor QGEM were brought to bear on transport investment in Queensland (for



⁶⁹ Documentation of the MMRF model admits that the subnational IO tables were 'synthetically created' (Allen Consulting et al. 1996, p. 48). A description of the IMP model names an 'Austroads' database as the source of information on origin-destination freight flows (NIEIR 1995b, p. 41). The database on freight flows appears to be FreightInfo, which measures flows in tonnes (FDF Management 1997). But an IO table measures trade flows in dollars and not just for freight.

BOX 9.7 TOP DOWN MODELLING OF STATE AND REGIONAL ECONOMIES

The BTE knows of only one application of the top down approach to Australian transport investments. The VFT study (CREA 1990) used a version of the ORANI model that distinguishes 'national' from 'local industries'.

The national industries cover most of mining, agriculture and manufacturing. By definition, they sell a large proportion of their production out-of-State. For each national industry, ORANI takes as given the distribution of production between States. Changes can be imposed, but this requires information from outside the model.

In the model, the production of the national industries forms the economic base for each State. The economic base drives the demand for the 'local' industries, which serve intra-State customers almost exclusively. Most of the service industries are 'local'. The MONASH model, as distinct from MONASH MRF, takes a similar 'top down' approach for State and regional economies (Adams & Dixon 1994).

The VFT would have carried some business passengers and freight. The cost reductions for this traffic might have attracted some 'national' industries to the VFT States (New South Wales and Victoria). However, the top down approach does not model such effects.

The top down approach can nonetheless throw *some* light on the effects of better transport. Strikingly, the CREA predicted that operation of the VFT service would have contractionary effects on the economies of New South Wales and Victoria. The explanation was that the VFT would be less labour-intensive than the transport services from which it would divert business. The consequent reduction in demand for transport workers was said to have negative multiplier effects on the economies of New South Wales and Victoria. These findings paint a part of the VFT picture, even if the top down approach omits other parts.

example, Swan Consultants and Booz, Allen & Hamilton Ltd 1998; Economic Insights 1996, 1998).

Both the MMRF and STATE models use apparently conjectural values for location choice parameters. In each model, purchasers of Australian products choose between States for their source of supply. The delivered prices influence this choice, and certain parameters, known as substitution elasticities, determine the strength of the influence. The elasticities determine, for example, the extent to which Victorian consumers change their source of supply for manufactured goods if the delivered price from New South Wales declines. But the values assigned to these elasticities are speculative.

Even some of the modellers agree that these values are 'arbitrarily set' or 'illustrative' (Matthew Peter, pers. comm., 15 September 1998, MMRF).

Data problems aside, the bottom up models of the Australian economy take a blinkered view of what drives the regional economies. They omit the influence on location decisions of non-business travel costs – the costs in time and, apparently, in money. Cheap and easy travel outside work hours (including commuter travel) increases the lifestyle appeal of a region. More residents gravitate toward the region and its economy expands. For some transport projects, the lifestyle enhancement may influence regional economies as much as the reduction in business transport costs. The Motorway Pacific, which would run from Newcastle to the Gold Coast, may be one such project (Tudge, Stewart & Nairn 1994, p. 125).

NIEIR (1995b) reports an exploratory analysis of how savings in nonbusiness travel time might affect regional economies. More advanced analyses might some day find their way into bottom up models of the Australian economy.

In the final analysis, however, bottom up models can indicate only broad ranges of magnitude at best. For the Australian economy at least, the models do not appear to have reached even this stage, since key parameters are chosen speculatively or with little explanation in available documentation. If the models were to reach this stage — and it is uncertain that they will — they would be of some use in evaluating transport investments. The regional development expectations of transport projects are often inflated. Broad ranges of magnitudes, if bottom up models can supply them, would provide a 'sanity check'. That said, dubious applications of such models can also generate unrealistic expectations (see Chapter 10).

The bottom up approach would seem to have more qualitative than quantitative potential. National economic models can highlight economic mechanisms that are easy to overlook. At an industry level, they have sometimes yielded findings that would contradict the intuition of most non-economists, but which are real possibilities (box 9.8). A bottom up model of the economy could well yield similar surprises for State or regional effects. Admittedly, the surprises are likely to become fewer after repeated applications. The applications, in essence, would provide a checklist of economic mechanisms.
BOX 9.8 INSIGHTS FROM NATIONAL ECONOMIC MODELS — AN EXAMPLE

IC (1991) simulated reforms to rail freight pricing using ORANI. The reforms would have adopted a 'user pays' system that would have reduced charges for grain and mineral shipments while raising them for general freight.

The simulation indicated that the reforms would reduce agricultural output, which may seem surprising. The cut in charges for grain transport would, by itself, increase agricultural output. But the cut in charges for mineral freight would, in the IC's analysis, cause agriculture to contract by even more.

Although this finding is open to challenge, it rests comfortably with economic theory. It exemplifies the well-known 'Gregory effect' (see Dixon et al. 1982, p. 351)

In the IC simulations, the reduction in charges for mineral freight causes a significant expansion of the mining sector. This expansion increases the demand for labour and other resources of the Australian economy. As a result, the cost of these resources increases. The increase in costs causes agriculture to contract, despite the cheapening of grain transport.

The astute reader may wonder: Why would the reforms cause mining to expand rather than agriculture? In the study under discussion, the IC simply notes that 'the mining sector is able to respond more readily than other sectors to cost reductions' (IC 1991, p. 35). Elsewhere, the IC attributes the greater responsiveness of mining to more favourable export demand conditions and to weaker resource constraints (IC 1990, pp. 224–225).

Effects on government finances

It is often argued that governments get some of their money back from transport projects through higher tax revenues ('fiscal clawback').

State governments in Australia sometimes argue this when requesting contributions from the Federal Government. Recently, such a request emanated from a proposal to increase mass limits for trucks. Implementation of the proposal would require major expenditure on bridge reinforcement. The benefit from the increase in mass limits would be savings in freight costs, leading to gains in national output. The Federal Government would receive most of the tax revenues on the additional output. So the States argued that it should also defray the cost of bridge reinforcement.

Some studies of Australian transport projects have estimated the effects on government finances using a national economic model. For a model to perform well at this, it must also do well at estimating the

effects on State and national output. Thus the preceding discussion in this chapter leads to the following assessment:

Models of the Australian economy will be of modest help in estimating the effects on State government finances. For the effects on State output, the models can give only broad indications at best.

For the effects on Federal Government finances, the case for a national economic model may be somewhat stronger. Weakening the case, however, are the problems in modelling investment, which will limit confidence in the estimates of real GDP gains.

BOX 9.9 GOVERNMENT BUDGET EFFECTS ON THE BACK OF AN ENVELOPE

Suppose that a project reduces the amount of labour required for a transport task. The annual savings in labour costs (including payroll tax) amount to, say, \$5 million. The project has no effect on aggregate employment, so the labour released from the transport task winds up employed somewhere else. As a first approximation, the labour that is released will produce \$5 million worth of output in the alternative employment (see Box 4.3). That is, national output (GDP) will increase by that amount. Federal tax revenues have amounted to about 23 per cent of national output in recent years (ABS 1997b, pp. 15, 52). So the back of the envelope suggests an increase in Federal tax revenue of \$1.15 million (= .23 x \$5 million).

One could expand this calculation to allow for savings in non-labour inputs, induced or displaced investment and so on. In doing this, one might extrapolate from simulations with national economic models, without going to the expense of new simulations.

Allen Consulting (1993) can serve to illustrate the possibility of extrapolation. The study used ORANI to simulate the effects of road investments during a 'typical year' after construction. The investments were hypothetical but somewhat representative of actual projects, with data being taken from a sample of BCAs. From the simulation results, one can calculate the ratio of real GDP gain to the resource savings that were the simulation inputs. These ratios, or 'multipliers', were mostly about 1.6, as reported by BTCE (1995c, p. 11). If one were prepared to accept this figure as representative — which it may or may not be — one could apply it to range of road investments. If a BCA indicates resource savings in a year of \$5 million, one could scale this figure up by 1.6 to arrive at an estimate of real GDP gain.

A customised application of a national economic model could be more reliable than the back of the envelope. But would the increase in precision justify the increase in expense?



When seeking estimates of the effects on government finances, people should carefully weigh the alternatives to a national economic model. In some cases, a 'back of the envelope' calculation might do nearly as well (box 9.9).

IN SUMMARY

Evaluations of transport investments may sometimes call for applications of national economic models. However, the evidence to date suggests that this will seldom be the case. Many applications are ill-conceived.

- Estimation of the net benefit can almost always proceed without national economic models. An estimate derived from a national economic model may incorporate a broader range of effects. But some of these effects do not matter much, and many, such as the impact on aggregate employment, are anyone's guess.
- Popular macroeconomic indicators, such as real GDP and the current account deficit, are of questionable relevance. An investment could benefit society greatly and yet increase the current account deficit, certainly during the construction phase and perhaps in the longer run.
- The existing models of the Australian economy do not provide reliable indications of State and regional effects of transport investments. There is a shortage of data on trade flows among States and regions.
- For some transport investments, models of the Australian economy could help estimate the effects on Federal Government finances. But 'back of the envelope' calculations can sometimes give estimates that are about as defensible, and at lower cost.
- Applications of national economic models are often costly. The costs include the effort that people make to understand the model and application. Full and transparent documentation can minimise this cost, and is essential for an assessment of the findings.



10

REGIONAL DEVELOPMENT EFFECTS

In Australia, benefit-cost analyses have been kinder to transport projects in cities than in rural regions. For major roads, the benefit-cost ratios have averaged about two to three times larger for urban than for rural projects (table 9.1).

People in the bush are therefore especially prone to criticise transport BCA. Often, they allege the omission of significant benefits from regional development. This chapter focuses, accordingly, on how transport projects affect the development of rural regions. Because 'regional' often has a rural connotation in Australia, many of the references to 'rural' are tacit.

In addition to being rural, the focus of this chapter is on the effects of realised improvements to transport infrastructure. The claims that regional development benefits are missing or understated refer more to the effects of the improvements, rather than to the effects of construction and maintenance activity. (See, for example, Weisbrod & Beckwith 1992, p. 76.) Employment creation, the major benefit claimed from the construction or maintenance activity, is discussed in chapter 5 of this report.

Claims that a transport BCA has omitted some regional development benefit raise several questions:

- What regional development effects would yield the benefit, and how large are they likely to be?
- Are the benefits to residents of particular regions, or to the society at large?
- Are benefits being measured, or simply regional impacts?
- Is the benefit really missing from the BCA estimates?

REGIONAL DEVELOPMENT EFFECTS: MAGNITUDES

A BTE economist recently heard from a professor of business at a major American university. The professor was reportedly interested in the implications of a highway project for the economy of his State. To find more case studies for this chapter, the BTE sent the professor an e-mail. The brief reply was mildly disconcerting:

'My first thought is that almost every "study" is ex ante and no one bothers to do an ex post follow up.

Second, most such studies don't count for anything.'

The professor's scepticism is understandable. Certainly, many estimates of regional development effects warrant a large pinch of salt.

To begin with, it is hard to trust an estimate without a clear idea of its derivation. Access to full and transparent documentation is normally needed. The documentation should provide enough information for others to be able to arrive at the same estimates ('replicability'). In addition, it should fully explain the logic for any assumptions.

By these scientific standards, many estimates of regional development effects are lacking.

Some estimates derive from models that are only partly understood by non-modellers. In this category is the IMP model, which has featured in several studies of Australian of transport projects (chapter 9).

Other estimates are derived impressionistically, without fully specifying a model.

Partly impressionistic, for example, was a study by Weisbrod & Beckwith (1992) of a large highway project across central Wisconsin. The researchers estimated the amount of new business that the highway would attract to the region. As part of this, they contacted local chambers of commerce and other organisations. Representatives of businesses and trade associations were asked about the importance of highway access to their location decisions, and the appeal of central Wisconsin locations. The researchers also weighed statistical evidence. For example, to gauge the costcompetitiveness of central Wisconsin, they compared the costs of inputs in the region with the rest of the United States (the costs of capital, labour and fuel). From these various sources of evidence, the researchers somehow arrived at their best guesses of business attraction impacts.



Researchers can only partly explain the derivation of impressionistic estimates such as these. Subjective judgment, which ultimately decides the estimates, has a logic that cannot be fully set out. The estimation procedures in the Wisconsin study were thus not documented to a standard of replicability (even in a more detailed version of the study: Cambridge Systematics 1989). Without such documentation, it is difficult for anyone to evaluate the estimates.

Impressionistic estimates are prone to bias. Often enough, the people whose judgements are counted would be the principal beneficiaries of the project being studied. Such informants are prone to wishful thinking and strategic responses. For example, local business representatives may attempt to sway opinion by exaggerating the implications of the project for regional economic growth.

Estimates, or claims, of regional development effects often conflict with the following hard realities:

For many projects, the reduction in transport cost is proportionally small.

For a community with only dirt roads, provision of paved roads could be a huge improvement. But quantum leaps of this sort are atypical of Australian BCAs of rural transport projects. The transport network that serves rural Australia is already well developed.

Moreover, an enhancement to the network will reduce only some components of transport cost. For example, a road investment may reduce the line haul costs for freight, but not the costs of loading and unloading. The savings in total transport cost will be proportionately smaller than the savings in line haul costs.

For these reasons, many rural projects will reduce regional transport costs by only a small proportion. In such cases, the stimulus to regional development will also tend to be small.

Parkes international airport

An example of this is the proposed international airport at Parkes, in central New South Wales.

As conceived, the airport would cater to dedicated freight services for export of farm products to Asia. The planes on these services would be dedicated 'freighters' that carry no passengers. Advocates of the airport stressed its importance for regional economic growth. A body owned by local governments, the Inland Marketing



Corporation, commissioned an evaluation of the project from consultants DJA Maunsell. The consultants found that an international airport at Parkes would significantly stimulate export growth (Asimus 1998, p. 22).

Pressure on the Government to support the project led it to commission an independent evaluation from Dr David Asimus, an expert on Australian agriculture. Dr Asimus won acceptance from the local governments as an impartial referee. Part of his brief was to review the Maunsell study, which had been unavailable for public review (executive summary; DJA Maunsell & CARE 1997).

Asimus challenged many of the Maunsell assumptions. A key assumption had set the proportion of air freight exports (by weight) that would be carried on dedicated freight services. Maunsell set the proportion at 70 per cent for the base case, where no international airport at Parkes is developed. (The proportion would have been higher for the development case.) The expectation was that only 30 per cent of the exports would go as 'underbelly freight', in the cargo section of scheduled passenger services from existing airports. The Maunsell justification ran as follows:

"... Worldwide, growth in freight is forecast to outstrip passenger capacity. Miami International Airport figures show that, by 2010, freight in freighters will be four times that in underbelly. To account for Australia's lag behind the USA, the existing Miami split of about 30% using underbelly was used" (The Maunsell study as quoted in Asimus 1998, p. 27).

Asimus noted that, in reality, underbelly services now account for 95 per cent of Australia's air freight exports. They dominate the market because they are cheap. The average rate for underbelly freight is \$0.60/kg, compared with around \$2.50/kg for dedicated freight services (estimates reported by Asimus 1998, p. 28). Maunsell assumed that the services from Parkes airport would charge an average of \$1.14/kg, still much above the cost of underbelly freight.

Services from Parkes airport would have to compete on quality to win much traffic. Dedicated freight services can have quality advantages, such as shorter transit times and specialised handling that offset their generally higher price. In the past, these advantages have attracted some traffic in products such as electronic components. Being high-priced relative to their weight, such products can fetch prices that cover the high cost of dedicated freight services. However, farm airfreight exports are mostly low-priced relative to their weight, and so have gravitated toward underbelly services. Even at the assumed rate of \$1.14/kg, dedicated freight services



from Parkes would be underutilised in the view of the airlines. Accordingly, the airlines were disinclined to operate such services (Asimus 1998, pp. 30–31).

In short, Australia already has advanced infrastructure in place for airfreighting farm products to Asia. An international airport at Parkes would be a minor addition to this infrastructure. Its effect on the cost of airfreight, even taking quality into account, would probably be slight.

An inland railway from Brisbane to Melbourne

The inland railway project is another example of transport projects having a minor impact on regional transport costs (BTCE 1996b, pp. 16–19). The proposed railway would reduce freight costs for farm industries in southern Queensland and northern New South Wales. Much of these savings would result from grain producers gaining better access to the port of Brisbane. However, the savings to producers on grain freight costs would be less than 3 per cent in each defined region.

Again, the existing transport infrastructure is already well developed. For example, farmers in northern New South Wales can rail-freight their grain to the port of Newcastle along existing lines. Having rail access to the port of Brisbane, which is nearer for some farmers, would reduce the ex-farm transport costs only slightly for each region. The smallness of the reduction partly reflects the fixed road component of costs. Grain moves by road from the farm to grain handling facilities, whence it may move by rail. For all practical purposes, one could assume, as did the BTCE study, that the inland railway would have no effect on the road cost of such trips.

Transport costs are generally not large relative to total production costs or revenues.

The inland railway would do little to stimulate grain production, because it would reduce grain transport costs marginally and because such costs are relatively small to start with. They amount to only about 12 per cent of the revenue from grain produced in southern Queensland and northern New South Wales. If the inland railway were to reduce grain transport costs by 2 per cent, the price to the farmers would increase by a mere fraction of a per cent.

More generally, freight costs within Australia are modest relative to total revenue or cost for most commodities. Freight costs beyond the farm gate account, on average, for only about 8 per cent of the price paid by Australian industry for domestic agricultural products. (Such purchases would include, for example, livestock acquired by meat processing plants.) For manufacturing and mining products, the figures are about 12 to 13 per cent (CIE 1995, p. 19).

Producers often view different modes of transport as poor substitutes.

The inland railway would probably be of slight benefit to horticultural producers. Rail transport carries only a small share of horticultural freight because it is usually inferior to road transport in speed, flexibility and product handling. The inland railway, by itself, would do little to overcome the drawbacks of rail.

For this, as well as other reasons, the railway would be unlikely to stimulate horticultural production in the traditional cotton growing areas of northern New South Wales (BTCE 1996b, p. 56). One of the originators of the inland railway proposal had seen this shift into horticulture as a possible source of benefit (Davidson 1995, pp. 2–3).

Natural constraints can limit the development of a region's resource-based industries.

Agriculture and mining underpin much of the rural economy in Australia and utilise a diverse range of resources. Insufficient attention to the diversity of these resources and to the natural constraints on their supply sometimes create unrealistic expectations of regional development effects.

In agriculture, the natural environment can lend a substantial commercial advantage to an area's traditional activities. Such is the case in the traditional cotton-growing areas of New South Wales. This is another reason why the inland railway would be unlikely to spread horticulture into these areas (BTCE 1996b, pp. 27–28).

In the world's driest continent, anyone claiming that better transport will spur agricultural development should also think about water constraints.

Maunsell predicted that an international airport at Parkes would significantly increase horticultural exports originating in New South Wales. Even without the proposed airport, the study predicted



phenomenal growth in such exports rising from 19,200 to 582,214 tonnes between 1995–96 and 2010–11. The projections were prepared by the NIEIR, using its model of the Australian economy.

However, constraints on supply of irrigation water suggest that these projections are highly optimistic:

While the growth in export production is assumed to come from a wide area of New South Wales, the summer rainfall areas in the north do not lend themselves to high-quality horticultural production. The bulk of the expansion would seem therefore to have to come from the Lachlan Valley or the Riverina. ... For [this] to be achieved, significant diversion of water from cotton production in the north of NSW [New South Wales] and from rice in the south would have to occur. Both industries continue to increase water use efficiency, both are profitable, well established and politically effective. It is hard to see any significant reduction in their size occurring as a result of Government action (Asimus 1998, p. 6).

Water constraints are also relevant to the proposed inland railway between Brisbane and Melbourne. The railway would reduce the freight costs for cotton from northern New South Wales, and for chemical inputs imported to the region for cotton production. But most cotton crops are irrigated; and it is the availability of water, not the current transport infrastructure, that is constraining cotton production (BTCE 1996b, p. 26).

Improved transport exposes a region's industries to greater competition.

Exports from a region become cheaper with improved transport access, but so do imports. Products from other regions and from abroad can crowd out the region's import-competing industries. For example, residents of the region may do their shopping elsewhere when their transport costs fall.

BENEFITS TO WHOM?

The population over which benefits and costs are measured (the 'population of standing') is a key consideration in BCA. It could be all humanity or a subgroup, such as residents of a nation or region. One can debate the choice on ethical and political grounds. A national government may estimate net benefits for its own people, disregarding spillovers to foreigners. To an internationalist, this practice may seem wrong. (Objections might also come from people



wanting to accord standing to animals, whose habitats come under threat from some transport projects.⁷⁰)

In Australia, BCAs of road projects generally do not delimit a population. Implicitly, they are measuring benefits to everyone, worldwide. Likewise for rail projects, which, together with road projects, account for the vast majority of transport BCAs.

It would be nice if an internationalist spirit explained the usual absence of distinction between Australians and foreigners. More likely, spillovers to foreigners are perceived as minor for most land transport projects and too difficult to estimate.

Information requirements increase when BCAs attempt to isolate the benefits for Australians. For international airports, the passenger traffic must be split by nationality. For seaports, one would need to estimate the effects of port improvements on export prices. Lower shipping costs are likely to reduce the prices (inclusive of shipping charges) that foreigners pay. The greater the reduction in price, the smaller is the remaining benefit for Australian producers. As was discussed in chapter 9, the extent of the price fall will depend on parameters, such as export demand elasticities, that are difficult to estimate.

The occasional BCA attempts to isolate the benefits for a State or region, necessitating additional information. Difficulties in obtaining such information often lead to arbitrary assumptions. Cost savings

If, on the other hand, the population of standing were to include the animals, the perspective would change drastically. Although monetary compensation to animals is not feasible, humans could take other steps to preserve animal welfare. In addition to building a noise barrier, they might restrict hunting, for example, or improve the animals' water supply. A package of such measures might leave the animals just as well off as before, despite the increase in noise. The benefit-cost analyst would want to estimate the cost of such a package, which would represent the cost of exposing the animals to noise. The cost could be substantial, even if humans were indifferent to the animals' plight. (If a compensatory package did not exist æ say the noise were to destroy the species, no matter what humans did-the benefit-cost analysis would have to rule out the project.)



⁷⁰ Threats to the habitats of native species, such as koalas and platypuses, have created stiff opposition to some Australian transport projects (see, for example, Miller 1999). To accord standing to animals is different from simply valuing human concerns about animals. To illustrate, suppose that a transport project afflicts some animals with noise. If the population of standing includes only humans, the cost of this impact depends on the degree of human sympathy for the animals. Sympathy can be measured in dollars: how much people would be willing to pay to spare the animals the noise. An analyst of the project might attempt to measure this willingness to pay through survey techniques.

Migration also complicates measurement of benefits to a State or region. Properly speaking, benefits accrue to populations rather than to a 'region' or other abstract entities. Defining the relevant population and isolating the benefits that accrue to it are tricky. Suppose, for example, that a transport improvement causes the economy of Queensland to expand. Queensland then attracts workers from other States. In defining the population of Queensland's beneficiaries, should one distinguish the newcomers from other residents, and if so, how?

The Wisconsin study

Many studies that measure welfare for a State or region simply dodge the migration issue. (If any studies of transport projects have dealt squarely with the issue, they are unknown to the BTE.⁷¹)

The study of the Wisconsin highway project, mentioned above, considered certain 'benefits to the economy' of the State. The measure of State economic welfare was the disposable personal income of Wisconsin residents. The study estimated the increase in State income that would result from certain effects of the highway improvement.

Some of the estimated increase appears to stem from in-migration. The reduction in road costs would stimulate industry in Wisconsin, creating employment opportunities that would draw people from other States. But the in-migrants would also earn labour income were they to remain in their original State. One must deduct this alternative income to derive the net benefit to the in-migrants. Since the study lacked such an adjustment, it did not properly measure benefits to all Wisconsin residents, including migrants. Nor did it measure benefit to the 'native' population alone. Such a measure would omit the Wisconsin income that in-migrants receive.

⁷¹ Hamilton et al. (1991, p. 337) also note the frequent evasion of the migration issue in the estimation of regional benefits from projects. The issue also arises outside project analysis. Morgan et al. (1996) attempted to deal rigorously with migration in measuring the effects of taxes on regional welfare. They estimated the effects of changes in State taxes on the welfare of the original residents.

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The population of beneficiaries is amorphous in the Wisconsin study for yet another reason. The study added measures of benefit that related to different populations. The 'economic development benefit' was the increase in State income. It related to a State population, albeit vaguely defined. Moreover, it excluded cost savings on existing automotive traffic. These savings formed a separate category called 'user benefits', which were measured without reference to who receives them — Wisconsin residents or someone else. And some of the cost savings on existing automobile traffic would accrue to people outside Wisconsin. (For example, some residents of neighbouring Minnesota would benefit from better access to Wisconsin tourist destinations.)

The study thus adds a measure of benefit to the global population (automobile cost savings), to a putative measure of benefit to Wisconsin residents ('economic development benefits'). The overlap between these populations raises the key question: Benefits to whom?

Some transport BCAs specify the population of beneficiaries more clearly. An analysis of the Brindabella road between Canberra and Tumut measured benefits globally and, alternatively, for the Australian Capital region (BTCE 1997a). Overlapping populations did not mingle within the same measure.

BENEFITS OR IMPACTS?

The Wisconsin study measured 'economic development benefits' without clearly specifying the beneficiaries. If only for this reason, the measure lacks a rigorous benefit interpretation. It is more an indication of regional impact.

The confusion between impacts and benefits is starker in some other evaluations of transport projects.

An example is an evaluation of two highway improvements in Texas, one near Fort Worth and another through Wichita Falls (Buffington et al. 1992). Certain 'non-user benefits' were added to the conventional 'user benefits' — the cost savings on existing traffic. Among the added benefits was the increase in gross sales of local retail and service establishments.

The rationale for this addition was unexplained. The apparent intent was to measure the benefit to the local populations from adaptations within the retail and service sectors to the highway upgradings. However, the measure of benefit that was selected was inappropriate for this purpose. An expansion of local retail and service activity



would increase costs as well as sales. In addition, some of any increase in revenue would flow to non-local owners of the affected businesses (such as corporate shareholders).⁷² Such problems are widespread in regional project analysis (see Hamilton et al. 1991, pp. 335–337).

In reality, the increase in gross sales is simply a measure of local impact. Even if it were somehow interpretable as a measure of local benefit, adding it to the globally measured user benefits would produce a measure without a clear interpretation (see the above discussion of the Wisconsin study).

If one were estimating benefits to a region, it is arguable whether benefits to migrants to the region should be included. And if they are included, they cannot be measured by the labour income that the migrants earn in their new home region. Such a measure would overstate benefits to migrants, as was explained in relation to the Wisconsin study (above).

If the intention were to estimate benefits for existing residents of a region, the labour income earned by migrants should not be counted as a benefit. Even if the migrants spent all their wages in the region, only a portion would end up as profits to local businesses, since provision of goods and services to the migrants would entail costs.

IS THE BENEFIT REALLY MISSING?

Now to benefit-cost analysis from a universalist perspective. The bottom line of such an analysis is the total net benefit, without discriminating among people. As was discussed above, this perspective prevails, albeit implicitly, in Australian road BCAs.

Regional development effects do matter in benefit-cost analysis, even from a universalist perspective. They can produce benefits (or disbenefits) for global society, not only for particular regions. For example, if an improvement to transport were to open up mining in some region, both the region and the world could benefit. A'regional development benefit' refers in the following discussion to a benefit for global society that arises from regional development effects.

⁷² The increase in local sales is even less a measure of global benefit, as it reflects local outcomes only. Adaptations in the retail and service sector could reach beyond the areas of the highway improvements. For example, a highway upgrade in Wichita Falls could attract business there from elsewhere in Texas.

Untruth and consequences

That regional development benefits lie outside conventional transport BCA is a major furphy. In reality, they enter some conventional measures of benefit, such as the CTCS. These measures are less narrow than their focus on transport outcomes might seem to suggest. Transport outcomes alone can measure many of the benefits from regional development effects and other responses to transport improvements (see chapter 2 and appendix II).

The delusion that BCA necessarily omits regional development benefits can lead to double counting. Warnings against this abound in a range of texts. For example:

All relevant costs and benefits should be included when evaluating a project but they should not be counted twice. ... For example, increases in agricultural output may mistakenly be claimed as additional benefits of, say, a road project when such benefits are already reflected in the usual measure of the social surplus on the transport services to be provided (Squire & van der Tak 1975, p. 24).

Double counting often results from adding increases in land values to conventional measures of benefit. (The Texas highway study, for example, appears to have so erred; Buffington et al. 1992, p. 61.) Imagine that some neighbourhood gains access to a highway. Local land values increase as the neighbourhood becomes more attractive. But this is merely a manifestation of the savings in transport costs, which a BCA would already count. So to add the increase in land values would be counting the same benefit twice.

Mountains or molehills?

The critics are partly right: some transport BCAs do omit regional development benefits.

Often, however, the omission is unlikely to matter much.

The induced traffic benefit is the conventional allowance for regional development benefits (chapter 2). It forms part of the CTCS, the other component being the cost savings on existing traffic. The regional development effects of a transport project create some traffic. For example, a road improvement that stimulates a local wheat industry will create more wheat traffic. The induced traffic benefit approximates the benefits from the underlying regional development effects.

But the regional development effects are often small, for the reasons discussed above. (The reduction in transport cost is proportionally



small, natural resource constraints operate, and so on.) In such cases, the associated increase in traffic will also be small. This is one reason why some BCAs forgo estimating the benefit from this traffic. The other main reason is the difficulty of estimation.

The critics are also partly right about the need for information beyond transport outcomes. The CTCS makes imperfect allowance for regional development effects, being only an approximate measure of benefit. Inefficiencies in the economy can impart errors to the CTCS, as can dynamic processes such as investment (appendix II).

Dynamic processes can entail adjustment costs that have a regional dimension. Painfully familiar to parts of rural Australia are the costs of adjusting to economic decline.⁷³ Such costs include, for example, the moving expenses of people who forsake their home town to obtain employment elsewhere. A transport improvement that revives a declining region could reduce the flow of out-migration and the associated costs.⁷⁴ Proper allowance for this benefit would seem to require more information than BCAs normally collect — information beyond transport outcomes.

Transport projects can also create adjustment costs that, likewise, BCAs would typically neglect. For example, a highway bypass could create relocation costs for traffic-serving business (box 10.1).

More generally, the errors in the CTCS that arise from regional development effects can go either way. That transport projects can create, as well as alleviate, regional adjustment costs illustrates this. It is wrong to assume, as some proponents of rural projects seem to, that errors necessarily cause underestimation of benefit.

It is also wrong to assume that the errors are generally large. The supporting evidence is simply not there. There is no reliable evidence from models of the Australian economy, including models with State and regional detail, that narrowing the focus to transport outcomes produces serious errors (chapter 9). Nor does such evidence emerge

⁷³ The areas of population decline in Australia are disproportionately rural and inland (Productivity Commission 1999, pp. xxiv-xxvi). Some areas have experienced sharp declines in population or employment or both. For example, the far-west region of New South Wales lost about one-third of its employment from 1981 to 1996 (Productivity Commission 1999, p. 46).

⁷⁴ If aggregate employment remains unaffected æ the assumption recommended in chapter 5 æ the employment gain in the revived region would create equal employment losses elsewhere. But the redistribution of employment toward an ailing region, which exports surplus labour, could well reduce the total flow of migration.

BOX 10.1 ADJUSTMENT COSTS FROM A HIGHWAY BYPASS

A highway bypass is constructed around a small town, where serving highway travellers had been an economic mainstay. Many of the residents have to move or commute farther to find other jobs. The residents bear costs from such adjustments, including possible emotional costs from moving to a new community.

Some of the traffic-serving establishments, such as petrol stations and restaurants, have to close and are left vacant because of limited alternative uses. New establishments that serve the town's former customers are built at a service centre along the highway. Since the abandoned buildings in the town would have lasted for some years, the bypass has effectively brought forward investment in business premises, at some cost to society. BCAs of highway bypasses would not normally factor such adjustment costs into the estimate of net benefit.

In reality, the adjustment costs from a highway bypass are typically less dramatic, even for small towns. The improved environment of the town usually benefits some businesses, such as motels that can better offer a quiet night's sleep (box 1.1).



from consideration of unemployment (chapter 5), lack of competition in product markets (chapter 8) or 'positive externalities' (chapter 12).

Moreover, other errors in transport BCA can swamp those relating to regional development. For example, the traffic forecasts for some projects may prove wildly optimistic.

Pickrell (1990) reviewed traffic forecasts for ten major capital improvement projects for passenger rail systems in American cities, each involving construction of a new line. All but one project attracted less than half the traffic that had been forecast.⁷⁵ Such gross errors are hopefully rare in transport BCA. But they illustrate the dangers of harping on one source of error, such as the omission of regional development benefits, when more serious errors may be lurking.

⁷⁵ The projects were constructed between 1971 and 1987. Actual traffic was measured for a single year for each project, somewhere between 1986 and 1989. For three projects, the forecast year had not yet been reached. For more on unrealistic expectations of urban public transport, see Mackett & Edwards (1998) and Pickrell (1992).

Retrospective checks on road traffic forecasts could be instructive. If understatement of regional development effects *were* a serious flaw in transport BCA, this should be evident in gross underforecasting of rural traffic.

Beware of loose language

Seskin (1990) reviewed three case studies of American highway projects. One was the Wisconsin study discussed above; the others were of highways in south-west Indiana and Boston. Each estimated regional economic effects in a framework that included the REMI model.

The review included a critique of 'traditional' highway BCA. Seskin characterised traditional BCA as measuring 'user benefits' alone, without accounting for regional economic benefits. The 'user benefits' are savings in the costs of travel time, vehicle operation and transport accidents. The regional economic benefits include 'the opportunities for business expansion, attraction, and tourism development' in a region that gains better highway access.

Seskin highlighted this 'key finding':

In each case [study] described, the application of a more comprehensive framework for the assessment of benefits generated a stream of [regional economic] benefits whose value was approximately 50 to 150 per cent of what would have been identified by reference solely to traditional user benefits (Seskin 1990, p. 32).

In an Australian road forum, John Cox drew attention to this finding. To him, it was evidence of significant 'nonuser benefits' that can be added to user benefits 'without fear of double counting' (Cox 1992, p. 36). This is a natural interpretation of Seskin's remarks. Seskin seems to be saying that traditional BCA would have seriously understated the benefits from the case study projects.

The standing of the REMI model reinforces the need to take Seskin's critique seriously. REMI appears to be one of the more widely used regional economic models in the United States. Reportedly, it is also relatively transparent, with detailed documentation being available to the public (Mills 1993, p. 30).

But the critique has several flaws:

Firstly, the population of beneficiaries is ambiguous. Recall the earlier discussion of the Wisconsin case study. The measure of regional economic benefit related to a vaguely defined Wisconsin population, and was really more a measure of impact than of benefit. Another

objection was to the mixing of apples with oranges. It is inconsistent to add measures of benefit that pertain to overlapping populations. The Wisconsin study added a measure of benefit for a State population to the user benefits for all humanity.

Further, if the measure of regional benefit pertained to a clearly defined regional population, it would still reveal nothing about the accuracy of traditional BCA. A traditional BCA could measure benefits accurately from its universalist perspective, even if its perspective could be challenged. The accuracy of a BCA is a separate issue from whether its perspective should be global, national or regional.⁷⁶

Seskin's references to 'traditional' measures of benefit are confusing. BCAs normally count savings in trucking costs among the benefits of a highway project. But in the case studies to which the above quotation refers, the 'traditional user benefits' omit savings in trucking costs. The Wisconsin study estimated the increase in State income that would result from the savings in trucking costs, and counted this as an 'economic development benefit' (in Seskin's terms, a 'regional economic benefit'). The 'user benefits' were merely the cost savings for automotive traffic.

One would also have to wonder about induced traffic benefits. In characterising the traditionally measured benefits as savings in transport costs, Seskin implies that they do not include benefits from induced traffic. Yet in Australia, BCAs of highway projects estimate an induced traffic benefit with reasonable frequency.

... and of buzzwords

Presumptions that certain regional development effects are especially beneficial are popular. Descriptions of such effects usually include a catchphrase.

The expansion of 'high value-adding' industries suggests, in some minds, a special benefit. However, this presumption is unwarranted.

An industry that is high value-adding uses relatively small amounts of materials and services in its production (see glossary). An example is the education industry. In 1993–94, the costs of material and



⁷⁶ Seskin does not make clear which perspective he favours. On the one hand, he stresses that regional development effects of highway improvements can produce a universal benefit. As he puts it, they 'increase the size of the economic pie' rather than simply redistribute slices of it between regions (Seskin 1990, p. 34). On the other hand, he uses measures of regional development benefit that pertain to regional [or State] populations.

service inputs amounted to only about 10 per cent of the education industry's gross output. This reflects the fact that the large bulk of the industry's costs stem from labour inputs. At the other extreme, material and service inputs amounted to 79 per cent of the gross output in meat and dairy manufacturing, where animals, rather than human labour, represent the main cost.⁷⁷

Now consider a road project that is likely to facilitate growth of a local university. In touting the regional development effects of the project, someone appends 'high-value adding' to 'university'. But does the high value-adding nature of education make the project more beneficial than another project that would stimulate dairying? No: the difference in value-adding is simply a difference in input mix. It does not make one industry intrinsically better than the other.

Likewise, there is no intrinsic merit to further domestic processing of rural commodities. Many Australians would like to see their economy move in this direction — for example, more conversion of wool into fancy woollens. The extra processing 'adds value' and that sounds good. But it also adds to costs, so there can be no presumption of an overall benefit. A transport project may stimulate some regional industry, but whether the industry produces elaborately transformed commodities or humble raw products establishes nothing about the project's merits.

Then there is the buzzword 'export'. In Australia, it appeals especially to advocates of transport projects in rural areas, which still generate much of the nation's export earnings. Why exports are better than production for domestic markets is seldom explained. One idea is that export growth improves the current account balance, leading to lower interest rates on Australia's external debt. However, there are weak links in this causal chain — in particular, that between the current account balance and interest rates (chapter 9). In addition, even without any weak links, there is another causal chain that has the opposite implication. An increase in exports that results from a transport improvement may depress export prices (chapter 9). The implication is that the improvement will benefit Australia more if it stimulates production for domestic, rather than export, markets.

⁷⁷ The estimates for each industry are derived from the ORANI database for 1993–94, supplied by the Centre of Policy Studies at Monash University.

IN SUMMARY

Regional development effects of transport projects are often likely to be small for one or more reasons:

- The project reduces transport costs by only a small proportion.
- Transport costs are not large relative to total production costs or revenues
- Producers view different modes of transport as poor substitutes.
- Natural constraints limit the development of resource-based industries.
- Improved transport exposes a region's industries to greater external competition.

Analysts should specify the population for which benefits are being measured. Is it a regional or national population, or all humanity? Dodging this question has produced measures of benefit that are impossible to interpret. Mistaking measures of regional impact for measures of benefit is also common.

Be careful of double counting as well. In Australia, most transport BCAs attempt to estimate the overall benefit to everyone, rather than to a subgroup, defined regionally or otherwise. Some of these analyses allow for benefits stemming from regional development effects. The allowance is often implicit in the induced traffic benefit, and so can escape some people's notice. The misunderstanding sometimes leads to double counting.



LOGISTIC ADAPTATIONS

Logistics include transport and related activities, such as inventory management and warehousing. Each element contributes to procuring or delivering a product. Improvements to transport infrastructure can induce logistic adaptations of various kinds. How BCAs should allow for such adaptations and the adequacy of conventional allowances are vexed issues.

HOW DO IMPROVEMENTS IN TRANSPORT INFRASTRUCTURE AFFECT LOGISTICS?

Adaptations to improvements in transport infrastructure can include the adoption of alternative transport technologies. A port may accommodate larger vessels after it has been widened or deepened. Better roads, to take another example, may allow the use of heavier trucks.

Improvements to infrastructure can also make transport cheaper, faster and more reliable, with or without the employment of alternative technologies. Each of these consequences has logistic ramifications, some examples of which follow.⁷⁸

Reductions in transport cost

A classic adaptation to cheaper transport is to cut back on inventory.

Consider a company that buys paper for its computers. The company consumes paper at a steady rate, and must decide how frequently to order shipments. With the rate of consumption fixed, ordering more frequently reduces the inventory of paper and associated costs in storage and interest. The drawback is a larger freight bill due to

⁷⁸ For more detailed discussions, see Allen, Baumel & Forkenbrock (1994); Rockcliffe (1996); or Das & Tyagi (1997).

the increased number of shipments.⁷⁹ However, this becomes less of a drawback when the cost of a shipment declines. So an improvement in transport infrastructure, by reducing the cost of a shipment, will encourage more frequent orders. The switch in strategy increases the company's transport costs but reduces inventory costs by even more.

Reductions in trip time

Reductions in trip time mean faster delivery, which can also affect logistic decisions.

One potential effect is warehouse consolidation:

In order to provide a speedy response to interstate clients, many firms are obliged to stockpile products around the country so that they can be delivered swiftly. For instance, a Melbourne-based manufacturer might have to warehouse in Brisbane or Sydney in order to guarantee delivery within 24 hours. By making it possible to deliver overnight, faster transport can enable such firms to reduce their number of holding points, which cuts inventory, sometimes dramatically. Presently, reliable next-day delivery to Sydney from Brisbane is difficult because the trip frequently exceeds 12 hours and therefore cannot be done legally by a single driver (Rockcliffe 1996, p. 185).

A reduction in the number of holding points, to flesh out this example, could cut inventory in at least two ways.

First, it could reduce inventory in-transit. If the manufacturer ships directly to Brisbane customers, rather than warehousing goods there first, the total transit time from Melbourne declines.

Second, the consolidation of warehouses increases the number of regions that each serves. The manufacturer in this example might eliminate the Brisbane warehouse once delivery overnight from Melbourne becomes possible, and serve Brisbane and other markets all from the Melbourne plant-warehouse. This reduces the need for precautionary inventory because the total demand from several regions is more stable than that from just one region. (The regionspecific fluctuations tend to average out to some extent.)





Since the amount of paper being consumed is fixed, more frequent shipments are also smaller. The freight bill increases because some costs of a shipment, such as a driver's time, are largely independent of shipment size.

Consolidation of warehouses can also produce benefits other than inventory savings. It can reduce the costs of warehouse operation by yielding scale economies (Quarmby 1989, p. 85). In addition, handling requirements decline if warehousing is consolidated at the production site (Mackie & Tweedle 1992, p. 106). The loading and unloading of trucks occurs once for direct shipments to Brisbane from a Melbourne plant/warehouse. It occurs twice when the shipments pass through a Brisbane warehouse.

Improvements in reliability of transport

Businesses adjust their logistic patterns in various ways when transport becomes more reliable. For example, a company will reduce its precautionary inventories of inputs when delivery times for these inputs become more predictable. (The company holds such inventories, lest late delivery disrupt production.)

DO BENEFIT-COST ANALYSES INCORPORATE LOGISTIC EFFECTS?

Some studies have denied or doubted that conventional BCAs of transport projects measure the bulk of the benefits from logistic adaptations (Aschauer 1982, p. 14; Allen et al. 1994, p. 40; FDF Management 1994, p. 40; Quarmby 1989, p. 84).

The critics are partly right, much as they are about regional development benefits (see chapter 10).

Analyses of road projects

Road BCAs vary in their allowances for logistic adaptations, and have drawn most of the critics' attention.

Allowances for the employment of heavier trucks are rare (Cox 1994, p. 82). An exception discussed below is the analysis of the Melbourne City Link (Allen Consulting et al. 1995, 1996).

Other omissions reflect the practices for valuing time-related benefits.

Rarely do road BCAs attempt to value predictability of journey time (chapter 4). Predictability is hard to measure, much less value. The almost universal practice in road BCA is to focus on average trip times, ignoring the random element. Adaptations to increased predictability are not modelled under this approach.

Traditionally, road BCAs have also neglected the value of time for freight contents. They routinely estimate the effects of time on



vehicle crew costs, and sometimes on certain other road costs such as the capital costs of the vehicle fleet (chapter 4). But the convenience benefits from faster delivery, such as savings in inventory costs, have usually been ignored.

During the 1990s, however, values of time for freight contents have become more widespread in evaluations of Australian road projects. The BTE has, for the present, incorporated into its RIAM model the values proposed by Austroads (1997b). In addition to being extremely speculative, the Austroads values vary only by type of vehicle. Further differentiation would be desirable because some commodities are far more time-sensitive than others, and the commodity composition of freight traffic varies between roads.

A recent econometric study (Wigan et al. 1998) took a step toward values of freight time that would be suitable for general use in Australian BCAs. It estimated the values that freight shippers attach to reliability — the percentage of deliveries that arrive on time — as well as savings in trip time (scheduled duration). Extensions to this research, which also estimated values for the risk of damage, are planned.

At present, the induced traffic benefit is the most common allowance in road BCA for logistic adaptations. A reduction in the cost of road transport elicits responses, including logistic adaptations, which create traffic. Estimation of an induced traffic benefit allows for the net benefits from such responses. (For the theory, see chapter 2, or Mohring & Williamson 1969.)

However, a fair number of road BCAs — in Australia — do not estimate an induced traffic benefit. A major reason is the difficulty in estimating the amount of induced traffic, whether from logistic adaptations or from some other source. In practice, most of the estimates are based on rough rules of thumbin the form of elasticities of demand (chapter 2).

Note: 'Induced traffic', as road BCAs normally use the term, excludes route-diverted traffic, which is estimated more often.

HOW LARGE ARE THE MISSING BENEFITS?

With road BCAs making limited allowance for logistic adaptations, some evidence on the significance of these omissions would be welcome. Unfortunately, the evidence is scant and inconclusive.



Industry case studies

Distribution of food and beverages has received particular attention in the relevant case studies.

British evidence

Quarmby (1989) examined the effects of higher road speeds on UK supermarket logistics, drawing on his experience as a top supermarket chain executive. The distribution network in his numerical example was hypothetical but intended to be realistic.

Statutory limitations on driving hours were central to Quarmby's story. The hypothetical network contained six warehouses in the base case. With any fewer, the distribution areas of some warehouses would become too large for drivers to do all their runs within the allowed hours. The modelled increase in road speeds was about 10 per cent from warehouse to supermarket. By design, the increase was just enough to allow five warehouses rather than six, without violating the hours limits.⁸⁰

The reduction in the number of warehouses created, in this example, cost savings from two sources. Economies of scale in warehouse operations accounted for three-fourths of the savings. The other savings were in precautionary inventory. As explained above, these arise because the demand for deliveries from a warehouse becomes more stable, the more areas the warehouse serves.

All together, warehouse consolidation accounted for 23 per cent of the benefits from the higher road speeds; the other benefits were the savings in transport costs that would occur without any logistic adaptations. Quarmby maintained that reasonable (but unidentified) assumptions could push this figure to between 30 and 50 per cent.

The realism of these calculations is questionable on at least two grounds, Quarmby's expertise notwithstanding.

First, the savings in precautionary inventory seem exaggerated. Implicitly, Quarmby assumed that fluctuations in demand for supermarket products are independent across areas (at least the temporary fluctuations that create a need for precautionary



⁸⁰ Implicit in Quarmby's calculations is that each hypothetical warehouse lies at the centre of a circular distribution area. The supermarkets are along the circumferences.

inventory).⁸¹ Independence implies that abnormally high (or low) levels of demand are unlikely to prevail simultaneously across many areas. More realistically, however, the demand fluctuations tend to be positively correlated across areas — so one would think. For example, a summer heat wave might cause a simultaneous increase in demand for beverages across areas of Britain. Warehouses that serve many areas may reduce the need for safety stocks of beverages, but by less than the independence assumption would imply.

Second, the role of statutory limitations on hours may have been exaggerated as well. In Australia, and presumably in Britain, these limitations are sometimes an impediment to warehouse consolidation, but not always. There are also ways around hours limits, legal or otherwise, such as paid rest breaks. Such measures could be economic when the benefits from warehouse consolidation are large enough.

Reinforcing the suspicion that Quarmby oversimplified is another UK study. Mackie & Tweedle (1992) modelled the distribution networks for a brewery and for a supermarket chain. For illustration, they simulated the effects of a 10 per cent increase in speeds on various roads, including, in one scenario, all roads. In their analysis, unlike Quarmby's, warehouse consolidation is possible even without an increase in road speeds. Indeed, they solved the cost-minimising number of warehouses, for both the base case and the increased speed scenarios. (Whether they incorporated statutory limits on hours is not mentioned, however.)

Mackie and Tweedle termed 'indirect' the benefits from logistic adaptations to the higher speeds. The 'direct' benefits were the savings in transport costs without such adaptations.

The contribution of the indirect benefits was judged to be 'small'. In all the increased speed scenarios, the indirect benefits comprised less than 20 per cent of the total benefit;⁸² exactly how much less



^{81 &#}x27;A week's cover of stockholding can be assumed to reduce in proportion to the square root of the number of depots' (Quarmby 1989, p. 85). The square root rule, which is well known in the logistics literature, depends on an assumption of independent demands (Coyle 1992, pp. 249–250).

⁸² Mackie & Tweedle (1992, p. 114). This appears to be the authors' meaning, although the reporting of their estimates is slightly ambiguous.

is not reported. This compares with Quarmby's range of 23 to 50 per cent. Alluding to Quarmby and (apparently) other work, the authors note: 'Other studies have attributed much greater indirect cost savings to road network improvements' (Mackie & Tweedle 1992, p. 114).

American evidence

The effects on supermarket logistics were also analysed for a proposed highway in Phoenix, the Paradise Parkway (Hickling Corp., Charles Rivers Assoc. & Christensen and Assoc. 1991). The indirect benefits arose from warehouse consolidation and more frequent deliveries to warehouses. They were estimated at 105 per cent of the direct benefits, which would accrue in the absence of these adaptations.

Limiting confidence in this estimate is the lack of any real explanation of its derivation. The explanation suggests that key inputs to the estimation are hypothetical. Exactly which elements are hypothetical and whether they can be regarded as realistic are not discussed. Also absent from the analysis is a check on whether logistic arrangements were optimal to start with, exploiting all opportunities for reducing costs. It is thus unclear whether the indirect benefits are fully attributable to the Paradise Parkway, or whether a portion would be achievable through better management alone.

The resulting estimate has received undue weight in other discussions. Cox (1992, p. 36) claimed that indirect benefits can add 24–105 per cent to the total benefit from road improvements, 'according to actual case studies'. The upper bound of this range is the estimate for the Paradise Parkway; the lower bound is Quarmby's estimate after minor adjustment.

BCAs of Australian road projects

In Australia, some road BCAs have paid special attention to logistic adaptations. Two such analyses are of large freeway projects in Melbourne.

The Melbourne Ring Road (FDF Management 1995)

The Ring Road analysed by FDF Management comprised a western segment, by then partly completed, plus eastern extensions. The estimated benefits included savings in inventory and warehousing

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costs, termed 'off-road' costs. The estimation of these savings was explained in some detail, though incompletely.⁸³

The savings in off-road costs added about 14 per cent to the other estimated savings in freight costs. For comparison with the case studies discussed above, which considered only freight transport, this is the most relevant statistic.

For a critique of BCA, however, what is more directly relevant is the contribution of off-road savings to total benefit, taking both freight and other transport into account. In the Ring Road analysis, this contribution amounted to less than 3 per cent. Omission of the off-road savings would thus have made little difference.

In other words, the analysts would have obtained almost the same estimate of benefit without considering logistic adaptations. Indeed, the difference between the estimates would have been even less than 3 per cent, had the analysts estimated the costs of induced traffic. Some of the logistic adaptations that would produce the offroad savings, such as more frequent deliveries, would create additional traffic. The analysts did not model this traffic and its associated costs.

The Melbourne City Link (Allen Consulting et al. 1995, 1996)

The BCA of the City Link included two categories of benefit that fall within the scope of this chapter.

Cost savings from changes in the truck fleet. Articulated trucks have lower costs per tonne-kilometre than do rigid trucks (Allen Consulting et al. 1995, p. 26). But they are mostly too large for some urban roads below freeway standard. The roads may be too narrow or twisting. Articulated trucks of usual size are even prohibited on certain roads.

The City Link will facilitate the use of articulated trucks on Melbourne roads. The resulting savings in truck costs will amount to \$50 million

⁸³ The square root rule underpinned the estimate of inventory savings due to warehouse consolidation. Quarmby also used this rule, which tends to exaggerate such savings. However, warehouse consolidation did not feature significantly in the Ring Road analysis, so exaggeration of the associated benefits would have had little effect on the overall picture (FDF Management 1995, p. 119; N. Rockcliffe, pers. comm., 26 February 1999).

in the year 2000–01, according to the BCA estimates. This compares with an estimated \$188 million in other transport cost savings from the City Link — savings of the sort more commonly estimated in road BCAs.

The modelling of mix-benefits thus was central to the analysis, adding about 25 per cent to the more familiar benefits.

The predicted change in fleet mix rested on an international comparison. In American cities, with their abundant freeways, articulated trucks account for a relatively high proportion of truck traffic. The analysts assumed that the proportion would be equally high in Melbourne, were it as well endowed with freeways.⁸⁴

However, factors other than road infrastructure also affect the prevalence of articulated trucks. One such factor is the proportion of traffic that is short- versus long-distance. Articulated trucks are more economical, the longer the trip distance. The average distance, along with other factors, could differ between urban America and Melbourne.⁸⁵

Switching to articulated trucks can create costs in less frequent service, or in measures to avoid this outcome, costs that appear to have been ignored. Being larger than rigid trucks, articulated trucks make fewer trips to carry the same freight volume. Fewer trips, in turn, could make deliveries less frequent, causing inventory to pile up. As well as higher inventory costs, a reduction in service frequency can impose inconvenience costs. (It would take longer to



⁸⁴ Specifically, the analysts calculated the differences between America and Victoria in: (a) the proportion of urban truck traffic that consists of articulated vehicles; and (b) the proportion of urban road traffic that moves on freeways. The differences were each positive, both proportions being higher in America. The ratio of the difference in (a) to the difference in (b) was 1.68. The analysts estimated that the City Link would increase the freeway share of Victorian road traffic from 15.8 per cent to 17.3 per cent, or by 1.5 percentage points. From this, they estimated that the articulated share of urban truck traffic in Victoria would increase by 2.5 percentage points (= 1.68 x 1.5).

⁸⁵ To speculate further, long distance trips might account for a larger proportion of truck traffic in urban America. Many American cities form a linked transport corridor, like that between New York and Washington, DC. To move between such cities, trucks may have to pass through one or more intermediate cities. The presence of such through-traffic would increase the proportion of urban traffic that is long-distance. Melbourne, on the other hand, is not highwayintermediate between other major cities.

receive goods after placing an order.)⁸⁶ Measures to maintain service frequency after a switch to larger trucks also entail costs. A fully loaded truck could set off more often, making deliveries to a larger number of establishments on each run. But the larger number of delivery points would make for a more circuitous route, increasing travel time and distance.

'Off-road' benefits from the City Link, as loosely described in the BCA, would consist mainly of savings in inventory costs. They were assumed to add 20 per cent to the project's other benefits, based on an analysis described as 'broad-brush'.

The analysis entailed two alternative approaches to estimating offroad benefits. After comparing the results, the analysts settled on the figure of 20 per cent. Each approach involved a number of working assumptions, and drew mainly on the evidence from the studies discussed above.⁸⁷

For freight moved by truck, the assumption in one approach was that off-road benefits would add 23 per cent to the other benefits. The analysts borrowed this estimate from Quarmby's (1989) analysis of supermarket logistics in the UK. (Quarmby's 'indirect' benefits are 'off-road' benefits in the terminology used for the City Link.) Not mentioned were the smaller estimates obtained by Mackie & Tweedle (1992).

As discussed above, the realism of Quarmby's estimate is open to question, even within its own context

Moreover, generalising it to the City Link takes the estimate out of its context. It is a long way from supermarket freight in the UK in the 1980s to all truck freight in Melbourne in the 21st century (when the City Link will be complete). Logistics have been changing rapidly in



⁸⁶ The same considerations apply to various transport projects that facilitate larger vehicles or vessels. For example, a BCA of a proposed improvement to Port Pirie observed that the reduction in service frequency would increase inventory costs (BTE 1975, pp. 31–32). However, it is unclear whether these costs were estimated.

⁸⁷ An exhaustive critique of the analysis would be tedious. For the record, however, the BTE has serious reservations in addition to those that are discussed below. These pertain to the arguments about rates of return and off-road benefits for light commercial vehicles (Allen Consulting 1993, pp. 29–30).

recent years, helped by advances in information and communication technology.⁸⁸

Even at present, Quarmby's scenario appears to have limited relevance to the City Link. True, an improvement in road transport can induce a reduction in the number of warehouses. But warehousing arrangements of the major supermarket chains in Australia are already highly consolidated. Typically, one or two warehouses in a capital city serve the entire State. It is far from certain that the City Link would induce further consolidation.⁸⁹

The other adduced evidence on 'off-road benefits' is likewise wanting. The sources of evidence were the analysis of the Paradise Parkway, the BCA of the Melbourne Ring Road, and a Swedish survey article (Engstrom & Wikberg 1992).

As was discussed above, the analysis of the Paradise Parkway inspires little confidence, while that of the Ring Road omitted the costs of induced traffic. In addition, the analysis of the Paradise Parkway has doubtful relevance to the City Link, for the same reasons as does Quarmby's (1989).

The Swedish survey notes that companies have sometimes greatly reduced their costs in 'material administration' — inventory management and the like — by increasing their reliance on road transport.

Ratios on the order of 5 to 10 can be documented, i.e. cost reductions from improved MA [material administration] to the tune of \$10 million entail cost increases of only \$1 million to \$2 million for increased transport (Engstrom & Wikberg 1992, p. 7).



⁸⁸ See OCECD (1992). Some of the advances are amazing, especially to people who can remember how things were several decades ago. A nice example:

^{&#}x27;The Coca-Cola Co. is collecting data from smart vending machines via cellular phones or infrared signals. A PC-based restocking program at the local bottler office analyses the data and produces a delivery slip that tells drivers which products and locations need to get stocked the next day' (Gates 1999, p. 50).

⁸⁹ The City Link might have other effects on supermarket logistics that are more significant than warehouse consolidation. More predictable delivery times, for example, would reduce the need for precautionary inventories and facilitate 'cross-docking' at warehouses (see glossary). However, Quarmby's evidence, as it relates to warehouse consolidation, offers no indication of the resulting benefits.

Accepting that such cases exist in Sweden — although the authors do not document them or name a source — they are not necessarily representative. Surely, the benefit-cost ratio to the company would sometimes be below the range mentioned. But the City Link BCA reports the ratios in this range without qualification.⁹⁰

IN SUMMARY

- Improvements in transport induce changes in logistic patterns, such as warehouse consolidation and reductions in inventories.
- In practice, BCAs have largely omitted or measured crudely some of the benefits from these reorganisations. The resulting errors would vary in importance between projects. The available evidence is scant and inconclusive.
- Recent research sponsored by Austroads is a first step toward remedying these problems in Australian road BCA. Extensions to this research are planned.



^{90 &#}x27;A Swedish study has found, for example that the internal business benefits of extra travel were 5 to 10 times this additional transport cost ...' (Allen Consulting 1995, p. 29). In addition to providing no evidence of such ratios being typical, the Swedish study did not specifically associate them with road improvements. Changes of various kinds, such as advances in information communication, could induce the adoption of more road-reliant logistics.

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POSITIVE EXTERNALITIES FROM TRANSPORT INVESTMENTS?

Opposition to some transport projects stems partly from concerns about environmental damage. In particular, road projects often prompt concerns about noise and air pollution from motor vehicles. These and other adverse environmental effects are cases of negative 'externalities'.

To some analysts of transport, the emphasis on negative environmental externalities seems dangerously one-sided (for example, Mudge 1997 and Willeke 1992). Surely, there are significant positive externalities as well?

More directly relevant to this report, it has also been argued that road BCAs fail to capture the alleged positive externalities:

However, even if carefully done, cost-benefit studies are generally considered to be unable to measure all the indirect benefits from many public infrastructure expenditure, primarily because of the benefit externalities associated with these projects which are difficult to identify and measure (Otto & Voss 1997, p. 139).

Other analysts have denied, or doubted, that positive externalities from transport really matter:

Positive externalities of transport play a growing role in the political discussion. If one concentrates on externalities of infrastructure use, it is easy to show that the number and relevance of positive externalities is low (Rothengatter 1994, p. 321).

Similarly, in discussing externalities in the transport sector, the BTCE confined itself to the negative, 'because of the limited number of positive externalities' (BTCE 1998, p. 1).

But what exactly does 'externality' mean?



Definitions vary and, unless the concept is trivialised, lack precision. Disagreements about the relevance of positive externalities to transport stem in part from this definitional ambiguity.

The classic and narrow definition, favoured in this report, runs so:

An 'externality' is an effect that one party has on another and that is not transmitted through market transactions.

Noise pollution from trucks, for example, satisfies this definition. Those driving the trucks disturb other parties, such as residents near a highway. A market transaction between these parties is absent.

Road congestion is another example of a negative externality. A driver who enters a congested highway reduces travel time for other motorists by adding to congestion. Again, there is no market transaction between the parties.

Claims that positive externalities are missing from transport BCAs have referred to all manner of effects. The temptation is to apply the term to almost any benefit that is thought to be missing. With such liberal application, many of the effects mentioned, such as reductions in consumer prices, come nowhere close to meeting the above definition. Used in much the same way is the term 'secondary benefit'.

For classic externalities that are positive and missing from a transport BCA, a natural place to search is the environment.

ENVIRONMENTAL EXTERNALITIES

Analyses that place money values on environmental effects are still the exceptions among transport BCAs, although they are becoming more common (for example, BTCE 1996d; Booz, Allen & Hamilton 1998). Additional research in this area should be encouraged.

For road projects, people tend to focus on the environmental costs. They often presume that non-valuation of environmental effects causes overestimation of net benefit.

But road projects can also have environmental benefits, which swamp the environmental costs in some cases. Some projects create an environmental amenity, such as the visual appeal of the Sydney Harbour Bridge. More common, however, is the mitigation of environmental damage. A town bypass, for example, can divert traffic noise and emissions from populated areas.



To take another example, freeway projects that relieve traffic congestion will reduce the stops and starts that make for high levels of vehicle emissions. One study reported 'a 50–100 per cent reduction in pollutants resulting from traffic moving from a uniform speed of 70–90 km/h compared to a start–stop operation at 20–50 km/h on our [Australia's] traditional urban arterial street system' (Cox 1994, p. 102). The contrary view that freeways add to noxious emissions focuses on the extra traffic that the freeways will attract. However, some of the traffic on new freeways represents a diversion of traffic from other roads, rather than a net increase in road traffic.

For rail projects, a common presumption is that they benefit the environment by diverting traffic from road transport (often the more polluting mode). As with the presumption that road projects harm the environment, reality can be more complex.

For example, whether an inter-urban rail project improves local air quality may depend partly on the locations of freight terminals. A study of the proposed inland railway between Brisbane and Melbourne cautioned:

The investments being considered would not necessarily relieve road congestion or problems with local air quality. The effects in capital cities are our main concern, since these problems are much less serious elsewhere. The ambiguity as to the direction of these effects follows from the reasoning in BTCE (1995c). Briefly, most intercapital rail freight will require distribution by road to and from the urban rail terminals, which are mostly located in the inner city. Consequently, a modal shift from road to rail will replace distribution by road from the outer suburbs (where the National Highway meets the urban area) with distribution by road from the inner city. Since congestion and air pollution are most severe in the inner city, the modal shift might aggravate these problems. Preconceptions about depollution effects can easily arise from ignoring these considerations, since, as a general rule, trucks do emit more pollution into the air than do trains, per tonne–kilometre of freight (BTCE 1996a, p. 52).

OTHER EXTERNALITIES

Economists sometimes label 'technological' an externality as defined above. Key to the definition is the absence of a market transaction between the parties imposing and bearing the external effect.

Pecuniary externalities

'Pecuniary' externalities, in contrast, are transmitted through market transactions. Definitions often emphasise transmission through
effects on prices (including those for labour). A shift in consumer demand from butter to margarine could reduce the price of butter. The adverse effect on butter producers would be a negative pecuniary externality; so would be any consequent fall in the price of milk.

Pecuniary externalities that are positive are sometimes claimed to be additional benefits to those which transport BCA normally measures. Such claims are generally mistaken and result partly from awkward terminology. Conventional measures of benefit from road improvements are based on road outcomes alone. A common term for the benefits so measured is 'road user benefits', which would seem to suggest additional benefits beyond those to road users. (A more technical term for the same measure is the 'change in transport consumer surplus'.)

The Australian Automobile Association, for example, appears to have fallen into this trap:

Externalities include negative externalities - the costs of road crashes (to the extent not covered by insurance), air pollution and urban traffic congestion – and positive externalities – benefits over and above those that accrue to road users such as enhancement of exports, contributions to the balance of payments, *and the flow-on savings to consumers, retailers and land developers* (italics supplied, AAA 1997, p. 1362).

In fact, such 'flow-on savings' are not 'over and above' the road user benefits in BCA. A road project that lowers freight costs for cotton lint will also benefit the parties downstream, such as consumers of cotton clothing. But to add such flow-on savings to the road-user benefits would be double counting (chapter 3).

Economists have long recognised this double-counting problem. For example, Prest and Turvey (1965) wrote:

An example ... is when the improvement of a road leads to greater profitability of garages and restaurants on that road, employment of more labour by them, higher rent payments to the relevant landlords, etc. in general, this will *not* be an additional benefit to be credited to the road investment, even if the extra profitability, etc., of the garages on one road is not offset by lower profitability of garages on the other, which are now less used as a result of traffic diversion. Any net difference in profitability and any net rise in rents and land values is simply a reflection of the benefits of more journeys being undertaken, etc., than before, and it would be double counting if these were included too. (p. 76).

Prest and Turvey further illustrated such double counting with benefit estimation procedures for irrigation projects (pp. 77–79).



Pecuniary externalities and economic efficiency

Many economists have taken the double-counting argument a step further. They have shown, within models of idealised economies, that transport outcomes alone can approximate the overall benefit of a road project. The approximation works best for economies that are highly efficient (chapter 3 and appendix I). If the approximation is close enough, information on road outcomes suffices for measuring the overall benefit for practical purposes: the pecuniary externalities — the flow-on costs and benefits — can be ignored.

If, on the other hand, an economy contains major inefficiencies, pecuniary externalities could be important for measuring the overall benefit. Appropriate allowances for pecuniary externalities are, however, tricky. To indiscriminately add them to the road user benefits would be extreme double counting.

Imperfect competition

Imperfect competition figures prominently among the potential sources of economic inefficiency. Private monopoly in its classic form creates an artificially high price, which, by reducing demand, keeps output to an economically suboptimal level. In an economy ridden with such monopolies, the road user benefits would, according to some common arguments, understate the overall benefit of a road improvement (chapter 8). The missing benefits would be pecuniary externalities that are positive.

But classic monopoly is only one form of imperfect competition, and even if it were the only form, it would not imply underestimation of benefit for every transport project: overestimation could also result (chapter 3). Moreover, oligopoly (domination of a market by several large producers) is a more common form of imperfect competition, and extremely hard to model (chapter 8).

Furthermore, the arguments about imperfect competition have a double edge. The same arguments that suggest underestimation of benefits from transport projects also raise the possibility that discount rates are too low, which would make projects look better than they really are (chapter 8).

For labour markets as well, economists have made only limited progress toward modelling imperfect competition (chapter 5). As a result, reliable estimates of employment-creation benefits from transport projects are unobtainable. Such benefits may or may not exist for a project; some projects might even decrease aggregate employment.

Agglomeration economies

Agglomeration economies are central to theories of economic geography. They refer to the 'decline in average cost as more production occurs within a specified geographical area' (Anas, Arnott & Small 1998, p. 1427).

External scale economies are one source of agglomeration economies. Unlike internal scale economies, which operate within a single company (chapter 8), external scale economies operate among groups of producers, such as a regional industry. They are often described as 'positive externalities' (as in Brain 1997, p. 85).

External scale economies could arise, for example, from on-the-job learning. Experience at the workplace gives people ideas for costsaving innovations. As an industry expands, the number of workers increases, which means more people to come up with such ideas. Moreover, innovations can spread beyond the firm from where they originated, to other firms in the same industry (a 'knowledge spillover').

Knowledge spillovers have received much attention in the 'new' theories of economic growth. (For reviews of this literature, see Pack 1994, other articles in the same journal issue, and BIE 1992.) It has been said, for example, that a new entrant into the computer industry can extract much of the knowledge that has gone into personal computers by inspecting the latest products on the market (Grossman & Helpman 1994, p. 37). Although the new entrant may be unable to simply copy existing products because of patent protection, it can apply the extracted knowledge toward developing its own computers.

Paradoxically, knowledge spillovers can lead to economic inefficiency, despite being beneficial overall. (In other words, they are less beneficial than they might be.) In weighing an investment in research and development (R&D), a company will pursue its self-interest. It will not count as a benefit the knowledge spillovers that other companies derive from its innovations. A consequence is that the company could reject an R&D investment that is worthwhile for society as a whole, but not for itself alone.⁹¹ Government contributions to private R&D (such as tax concessions) can only partly remedy such divergences between private and public interest.



⁹¹ Internal scale economies present the same sort of paradox. Although they benefit society, they are not as beneficial as they would be in an ideal economy. In real economies, they can lead to economic inefficiencies associated with imperfect competition (chapter 8).

Agglomeration economies and transport BCA

A few more observations will clarify the connections between the above ideas and transport BCA.

Agglomeration (the geographic concentration of economic activity) facilitates knowledge spillovers. People can better learn what is happening, the closer they are to the event.

Transport projects can affect the degree of agglomeration. Some theoretical work suggests that a decline in commuting costs may foster agglomeration. (See the discussion of Fujita's work in Anas, Arnott & Small 1998, p. 1447.) Discussions of public transit investments also mention agglomeration economies:

Transit affects land-use and economic activity in different ways than highway systems. Generally, transit can sustain more concentrated land-use patterns ... A concentrated land-use pattern also can lead to more interpersonal contacts, increased networking, productivity and community interaction (Beimborn & Horowitz 1993, pp. 19–20).

Some of the agglomeration economies that arise in such cases escape measurement in a conventional BCA. The conventional measures of benefit, which are based on transport outcomes alone, may be adequate for a perfectly efficient economy. However, as discussed above, some sources of agglomeration economies can create inefficiencies, despite being beneficial overall. Knowledge spillovers are at an inefficiently low level because the people from whom they emanate do not fully reckon them as a benefit. A transport project that increases such spillovers will have benefits not measurable from transport outcomes.

But only some transport projects foster agglomeration; others may cause dispersion of economic activity. For example, some rural transport projects in Australia may draw economic activity back to the bush, away from the urban agglomerations. (Granted, such scenarios often have an element of delusion; chapter 10.) In urban areas as well, transport projects do not necessarily increase agglomeration.

For other reasons too, agglomeration considerations do not support strong conclusions about transport BCA.

Lack of connection to economic inefficiencies

Unlike knowledge spillovers, some of the claimed agglomeration benefits lack a clear connection with economic inefficiencies. Without



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such a connection, they indicate little about the adequacy of conventional BCA.

For example, a common claim is that public transit investments will have agglomeration benefits in reduced costs for non-transport infrastructure. Beimborn & Horowitz (1993) describe these cost savings:

With concentrations of activities, public services become more efficient. There is a reduced need for sewer, water, and other utilities with higher densities. [The pipes, wires etc. need to cover a smaller area.] Services such as police and fire protection may become more efficient with less land areas to cover. Furthermore, operating costs of these services may become smaller per unit of delivered services because of the concentration of activity. (pp. 19–20)

However, that some people choose to live in low-density suburbs with high infrastructure costs establishes nothing about economic efficiency. The charging policies of the infrastructure providers, such as the water authorities, also enter the picture. Under economically efficient pricing of infrastructure, the low-density suburbanites bear the increased costs of infrastructure that their location choice creates. People who adhere to that choice under such a policy are deriving some benefit from living in the suburbs, such as cheap land, that outweigh the higher infrastructure costs. If, on the other hand, the suburbanites are not charged for the higher infrastructure costs, the pattern of settlement will be distorted: too many people will choose to live in the suburbs.

For the record, the Industry Commission investigated possible inefficiencies in the pattern of urban settlement in Australia. From the available evidence, it could *not* confirm that infrastructure policies were subsidising settlement on the urban fringe (IC 1993, pp. 4–6).

Pervasiveness of externalities, positive and negative

Positive externalities similar to those claimed for transport projects are imaginable, and sometimes quite plausible, for just about any economic activity. For example, knowledge spillovers can be claimed for investment in telecommunications. The pervasiveness of positive externalities raises the possibility that discount rates are too low, which would create too rosy an impression of transport projects.

Then too, transport projects can have negative externalities beyond the environmental effects that draw so much attention. For example, one speculation is that public transit investments might increase crime rates by fostering urban agglomeration (Beimborn & Horowitz 1993, p. 20).

'Positive externalities' - the list goes on

Otto and Voss (1997) characterise as 'external' the benefits from some adaptations to road improvements. As one of several examples, they describe adaptions in labour markets:

A related effect of improved transportation networks is improved access to input supply, in particular labour supply. This improves the ability of the firm to hire the most appropriate staff and gives staff more flexibility in their work arrangements both of which may lead to increased labour productivity and hence lower costs (Otto & Voss 1997, p. 147).

But such benefits are measured in some conventional BCAs. They show up in the allowance for induced traffic, which forms part of the measured change in consumer surplus (chapter 2). A classic work on benefit-cost analysis explained this long ago, using a hypothetical new railroad for concreteness:

... if this new railroad so reduces time and increases the convenience of travel as to offer new job opportunities to a number of men, we ought *not* to include the measure of these new rents (a measure of the increase in their welfare from switching to the new jobs) as *additional* benefits. For such benefits are already included in the (potential) consumers' surplus of the new railroad. Such a measure of consumer's surplus—approximated, say, by an estimate of the potential demand schedule for train journeys per annum—reveals the maximum sum each person will pay for a number of train journeys. And in determining this maximum sum, he will take account of the rents of the new job and, indeed all other incidental utilities and disutilities accruing to him from the new railroad service (Mishan 1975, p. 79).

More generally, allowances for indirect benefits (from adaptations to road improvements) are fairly common in road BCA. Although they are often crude, it is unclear whether the flaws in measurement have caused systematic and significant underestimation of benefit. In some analyses, they could lead to overestimation, as may have occurred, for instance, in the estimation of logistic benefits from some road projects in Melbourne (chapter 11). See also chapters 2 and 10 of this report.

In addition to logistic adaptations, Otto and Voss mention modal diversion as a source of external benefit⁹²:

One immediate re-structuring response of firms (and consumers) to improved road transportation would be to substitute away from other forms of transportation, rail transport being the most obvious example. (p.146)

However, diversion from other transport modes would appear to be only a minor source of benefit for most Australian road projects. Investments in intercity highways can lure some long-haul freight from railways to trucks, but such traffic is nevertheless a minor determinant of the need for these investments (BTCE 1995b, pp. 117–118). Far more important are light vehicles and local or regional traffic (for which rail alternatives are often non-existent or very inconvenient).

MACROECONOMETRIC EVIDENCE ON THE BENEFITS FROM INFRASTRUCTURE INVESTMENT

Macroeconometric analysis produces broad generalisations about economic relationships by applying the statistical tools of econometrics to highly aggregated data. One area of application is the estimation of a national 'production function', in which the quantity of output depends on quantities of inputs. Production functions have also been estimated using highly aggregated data at a subnational level, such as state or province.

Many such analyses have attempted to quantify the contribution of public infrastructure to private production.⁹³ 'Public infrastructure' in these analyses normally refers to government-owned fixed capital



⁹² Otto and Voss also suggest that road improvements have external benefits in growth of exports and private investment. The comments about private investment are so heavily qualified, however, that the overall message is unclear. The comments about exports are also somewhat hard to interpret, and the focus on benefits seems one-sided. An induced increase in exports can produce costs, as well as benefits, that BCAs fail to measure: see chapter 9's discussion of exports and the current account deficit.

⁹³ Public infrastructure is also an input to public production, but public output is hard to value because much of it is not sold. For this reason, the econometric evidence on the productive role of public infrastructure comes largely from analyses of private sector production functions. Some of the evidence also comes from studies that estimate a 'cost function', but the differences from the production function approach have little relevance to the present discussion.

(equipment, buildings and structures). Some analyses examine components of public infrastructure, such as the road network; others simply look at public infrastructure as a whole. Attempts at fine breakdowns often run into data constraints.

The generalisation that an increase in the stock of public infrastructure (or some other component) enhances private productivity would be uncontroversial. Examples come to mind easily, such as the contribution to private production of the highway network. Controversy has arisen because some of the estimated contributions are phenomenally large.

Aschauer (1989) led the way with his striking findings for the US: for 1991, they imply that an additional \$1 billion of infrastructure in place would have boosted private sector output in that year by \$940 million or more.

Such a large estimate of returns is remarkable, particularly as it relates only to private sector output. Public infrastructure also facilitates production in the public sector, and has direct benefits for consumers (savings in travel time for shopping trips, enjoyment of parks and museums, and so on).

Estimates of huge returns to public infrastructure, for both the US and other countries, continued to appear in follow-ups to Aschauer's work. Some of the estimates have been specific to transport infrastructure, including Australian roads (Otto & Voss 1993, 1995, 1997).

Such estimates have also met with widespread scepticism, including in a review of the literature from an Australian transport perspective (BTCE 1996a). Aschauer himself observed that the estimates are 'high indeed compared to those of conventional cost-benefit analyses'.

Aschauer suggested that 'this could conceivably be due to deficiencies in the cost-benefit methods which tend to understate the true return to public capital accumulation'. The alleged sources of understatement included two that have attracted attention under the umbrella term 'positive externality': logistic reorganisations and expansions of labour market catchment areas (Aschauer 1992, pp. 13–15). Similarly, Otto and Voss (1997, p. 141) credited macroeconomic analysis with potential to capture 'indirect benefits' that 'project-based cost-benefit analyses do not always adequately measure'.

In fact, the macroeconometric findings vary too much to suggest anything about the adequacy of BCA. Kelejian & Robinson (1997) could not even confirm that infrastructure is productive, after conducting extensive sensitivity tests. BTCE (1996a) summarised their findings (based on a preprint of their paper):

Analysing US data on the 48 continental states from 1972 to 1985, the authors [Kelejian & Robinson] could not confirm that infrastructure has positive effects on private output, let alone that the effects are large, despite their attempts to capture spillover effects across States. Only their basic model specification produced significantly positive estimates of infrastructure payoffs. Specifications that incorporated complications ignored in the basic model produced corresponding estimates that were mostly negative and significantly so in some cases. The complications considered would be familiar to economists: fixed state-level effects; autocorrelation; heteroskedasticity; endogeneity of some explanatory variables ... None of these complications are spurious ones designed to produce a certain result. (p.4)

Likewise, a recent analysis of US data could not confirm that additions to road infrastructure after 1973 boosted productivity (Fernald 1999, pp. 631–632). The estimated contribution was positive but statistically insignificant.

The variation in findings stems partly from their sensitivity to small changes in data. BTCE 1996a) gave as examples:

Ratner (1983) obtained an estimate of 0.06 for the elasticity of US private sector output with respect to infrastructure, meaning roughly that a ten per cent increase in infrastructure raises output by 0.6 per cent; Tatom (1991) re-estimated Ratner's model using revised data for the same sample period, and obtained a much larger elasticity estimate, 0.28.

Aschauer (1989) estimated the elasticity of US private sector output with respect to infrastructure, using annual data from 1949 through 1985. Nienhaus (1991) found that adding data for the next two years, 1986 and 1987, substantially reduced the elasticity estimate based on Aschauer's model, from 0.39 to 0.24. (p.12)

A more recent example is a macroeconometric analysis of productivity in the Australian private sector from 1959 through 1992 (Voss 1996, pp. 5–6). Again, the last two years of data were decisive. Only with their inclusion was there statistically significant evidence that additional public infrastructure raises private sector productivity.



Serious deficiencies in the macroeconomic data exacerbate the datasensitivity of the findings. In particular, national accounts make inadequate allowances for improvements in product quality, and so underestimate growth in output and capital stocks. The measurement problems are greatest for rapidly changing products like computers:

In the US, the adoption of a more accurate method of allowing for quality improvements in computer manufacturing-the so-called 'hedonic' method-produced sharp upward revisions in the national accounts estimates of that industry's real output growth. Productivity growth in US manufacturing looked much stronger as a result, with one-third of the total growth during the 1980s due to this adjustment alone (Gordon 1993). This has been the only hedonic adjustment for guality change in the US national accounts, according to Griliches (1994), despite similar, if less extreme, problems existing for products other than computers. The same situation prevails in Australia, where the less accurate but easier method of quality adjustment-the 'matched model' method-is applied to non-computer products. For the US, there are indications that the use of hedonic methods for all producer equipment (not just computers) would substantially raise the estimated growth of the private capital stock. For the period 1947-1983, the estimated growth rate would increase from 3.51 per cent per year to 5.11 per cent, according to estimates in Gordon (1990). (BTCE 1996a, p. 14)

The BTCE's 1996 assessment of the macroeconometric research on infrastructure still rings true, taking more recent evidence into account:

BTCE doubts the value of further macro-econometric research on infrastructure payoffs. Aggregation bias aside, such research has serious limitations arising from the nature of the data used. Macroeconometricians are not in the position of some natural scientists, who can conduct a vast number of experiments and vary one thing at a time. Rather, they must make do with such variation as has arisen, which will often be insufficient to reliably estimate the effects of interest, even when time series are combined with cross-sections. Large errors in the available data, such as underallowances for improvements in product quality, make the prospects for analysis bleaker ... As Gramlich observes, these studies have already commanded resources 'way out of proportion' to whatever might be learned from them. (BTCE 1996a)

IN SUMMARY

• Valuations of the environmental effects of transport projects have been rare in transport BCA, but are becoming more

common. These effects can be positive or negative and are true externalities.

- Transport projects can produce externalities aside from environmental effects that BCAs fail to measure, such as those arising from knowledge spillovers. But such externalities pervade the economy and can be negative as well as positive. They do not necessarily cause BCAs to undervalue transport projects.
- Claims that transport BCAs have not valued some 'positive externality' are often mistaken, although the valuation may be crude.



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MULTI-CRITERIA ANALYSIS

Objections to benefit-cost analysis (BCA) have ranged from its ethical and philosophical underpinnings to its heavy reliance on monetary valuations, and the alleged omission of factors for which money valuations are difficult or impossible (Williams 1972 reviews some of the issues). An alternative evaluation method that is often put forward is multi-criteria analysis (MCA).

Exactly what constitutes MCA is hard to say. There appears to be no established theoretical framework or uniform set of principles. As a result, different analysts can apply quite different criteria to the same project. Terminology also varies.

Applications of MCA to transport projects in Australia appear to have been limited (BTE 1984; RAC 1992, p. 7; PIARC 1998, table 4.1). Although usage may now be increasing, the BTE was unsuccessful in its informal approaches to personnel in various State road authorities for a 'live specimen' of an MCA. For these reasons, this chapter presents only a broad commentary on the MCA techniques.

Abelson (1994, p. 19) considers that most MCA methods are variants of 'utility value analysis' (sometimes called 'decision analysis'). For all practical purposes, however, it is probably useful to distinguish the two major techniques in current use: the goals achievement matrix (GAM) and the planning balance sheet (PBS).

THE PLANNING BALANCE SHEET METHOD

According to Lichfield, Kettle and Whitbread (1975, p. 78), the planning balance sheet method was developed by Lichfield during the 1950s and 1960s, primarily for urban and regional planning proposals.

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Development of the PBS was intended to overcome the perceived failure of BCA to 'conveniently bring out the incidence of costs and benefits on the various groups affected' (Lichfield et al. 1975, p. 61). For each group likely to be affected by a project, the PBS approach attempts to estimate net benefits, using the same estimation techniques employed in BCA. In contrast to the goals achievement matrix method (below), PBS does not involve any weighting of effects 'because of the difficulty of ascertaining a relevant set of ethical judgements from the decision-takers' (Lichfield et al. 1975, p. 80).

In PBS, major groups within the community are identified as either 'producers' or 'consumers', 'since the favourability of a particular scheme tends to vary considerably between these two groups' (Alexander 1978, p. 50). The analyst specifies the objectives of each group. Costs and benefits are estimated against the objectives or 'aspirations' of each group.

Alexander (1978) illustrated the application of PBS analysis with two case studies. One of the studies was an evaluation of five alternative strategies for the future development of the Blue Mountains area to the west of Sydney.

Table 13.1 shows the groups involved in the Blue Mountains study, their objectives and the measures used. The actual table presented by Alexander includes five more columns showing the net cost or benefit of alternative project strategies, or a qualitative score where monetary values were not estimated. A further five columns rank these strategies according to relative monetary value or qualitative score. Column totals are provided for each strategy by summing the ranked values; the total for 'producers' being added to the total for 'consumers'.

The table presented by Alexander (1978) seeks to cover all stakeholders. However, given the aggregation of results, there is almost certainly double counting involved. For example, the Department of Urban and Regional Development (DURD) and the Planning and Environment Commission (PEC) both nominate protection of the environment as an objective. (The measure shown for DURD is the dollar value of land-resumption costs. No measure is specified for the PEC, but scores on an ordinal scale are allocated to each of the five options under consideration: not shown in table 13.1.)

Both agencies presumably exist to reflect environmental preferences on behalf of the community, but the PBS table further adds in the environmental preferences of consumer groups such as non-resident ratepayers, and travellers and visitors to the region. The resulting

	Groups	Objective	Measure used
PRODI	UCERS		
1.0	GOVERNMENT		
1.1	Urban and Regional Development	Conservation of environment as far as feasible	Resumption costs
1.2	Planning and Environment Commission	Implementation of Scheme, Environmental protection	-
1.3	Main Roads	Efficient transport to and from area at minimum cost	Substantial new road works required
		Catering for though-traffic	
1.4	Public Transport Commission	Efficient transport, keeping up with traffic growth	New facilities required
		Maintaining efficient West line service	
1.5	Lands	Economic sales of land reserves	Revenue
1.6	National Parks Board	Extending boundaries where possible	-
		Conservation of park attractions	
1.7	Tourist authorities	Maintain and develop tourist potential	-
1.8	Education	Adequate provision of schools	Number of schools required
1.9	Health	Adequate provision of health services	Facilities
1.10	Fire Protection Authorities	Minimum fire risk	Fire control cost
1.11	Decentralisation	Build-up of light industry	New industry jobs
1.12	Forestry Commission	Economic maintenance and cutting of State Forests	Revenue
1.13	Water Boards	Protection of catchment areas	-

TABLE 13.1 PLANNING BALANCE SHEET FOR DEVELOPMENT OPTIONS IN THE BLUE MOUNTAINS

TABLE 13.1	PLANNING BALANCE SHEET FOR DEVELOPMEN		
	OPTIONS IN THE BLUE MOUNTAINS (continued)		

	Groups	Objective	Measure used		
PRODU	PRODUCERS (continued)				
1.14	Electricity and Communications suppliers	Economic and adequate service for population	Lots to be serviced		
2.0	COUNCIL	Housing for a wide variety of socio- economic groups	-		
		Efficient service provision for population			
		Minimum loss of rateable land	Additional service cost per head		
		Efficient provision of social facilities	Forgone revenue Rateable income		
3.0	BUSINESS COMMUNITY	Maximum trading potential	Population		
4.0	INDUSTRIES	Large workforce pool	Industrial workers Acres for Industry		
		Suitable land and conditions			
5.0	DEVELOPERS	Maximum development potential	New building lots		
CONSL	JMERS				
6.0	RESIDENTS				
6.1	As ratepayers	Upper Blue Mountain Area representation of views	Votes for each alternative		
		Lower Blue Mountain representation of view			
6.2	Older residents	Greater variety of housing types	New medium density housing (acres)		
6.3	Conservation groups	Minimum pollution and maximum conservation of environment	-		
6.4	Anti-flat groups	No further flat development	New areas of flats (acres)		
6.5	Progress associations	Improved social and civic facilities	-		



	Groups	Objective	Measure used
CONSU	JMERS (continued)		
6.6	Youth	Improved social opportunities	-
		Improved employment opportunities	New local jobs
6.7	Land owners	Enhancement of property values	-
7.0	NON-RESIDENT RATEPAYERS	Maintenance of environment	Votes for each alternative
8.0	TRAVELLERS		
8.1	Commuters - rail - road	Improved transport to and from area	Number of commuters
8.2	Through-traffic	Ease of movement through area	-
9.0	WORKFORCE		
9.1	Retail and office	Greater local work opportunities	Proportion able to work locally
9.2	Industrial	Greater local work opportunities	Proportion able to work locally
9.3	Tourism	Greater local work opportunities	Proportion able to work locally
10.0	SHOPPERS		
10.1	Lower Blue Mountains	Improved local shopping	Number of District Regional Centres
10.2	Upper Blue Mountains	Improved local shopping	Number of District Regional Centres
11.0	VISITORS AND TOURISTS		
11.1	Day trippers	Maintenance and improvement of facilities	-
11.2	Holidaymakers	Maintenance and improvement of facilities	-
		Protection of environment, views, etc	
12.0	PROSPECTIVE	Pleasant environment	-
	RESIDENTS	Low-cost housing Good social facilities	-

TABLE 13.1 PLANNING BALANCE SHEET FOR DEVELOPMENT OPTIONS IN THE BLUE MOUNTAINS (continued)

Note The table has been abbreviated by excluding the actual scoring results for the five alternative strategies that were evaluated.

Source Alexander (1978, pp. 56–59).



over-representation of environmental effects is likely to result in a misleading basis for decision-making.

It is not clear whether Lichfield would recognise the Blue Mountains case study as a valid example of the PBS method. For a start, it adds together the ranks of strategies, so there is implicit weighting. Further, some of the objectives and measures used are problematic. For example, 'new facilities required' is given as a measure of the objective 'efficient transport, keeping up with traffic growth' (item 1.4): an increase in capacity will not necessarily improve efficiency.

Further, Lichfield et al. (pp. 69–70) accept the need to express values, as far as possible, in common monetary units. Alexander (1978, p. 60) himself criticises his own case study for failing to express in money terms the costs of the extra transport facilities required under categories 1.3 and 1.4 in table 13.1. But he appears to excuse the omission because of 'time and resource constraints', arguing that the framework nonetheless 'did prove useful as a means of illustrating the issues involved in the choice of an alternative' (p. 55).

This rationalisation sits rather at odds with Alexander's apparent acceptance of criticism of the inadequacies of benefit-cost analysis. More importantly, it begs the question of how the PBS method should be assessed. If 'illustration' is considered to be more important than the evaluation of alternatives, decision-makers will gain little concrete advantage from using PBS rather than BCA to guide them in choosing between options.

THE GOALS ACHIEVEMENT MATRIX METHOD

The goals achievement matrix (GAM) method is perhaps better known than the PBS method. In contrast to PBS, its primary focus is on selected socio-economic objectives⁹⁴, rather than the effect on community groups. It does not seek specifically to focus on sectoral interests, and does not require effects to be expressed in monetary values. Objectives are usually weighted to reflect their relative importance to the analyst or the decision-maker.



⁹⁴ These objectives are also variously known as 'impacts', 'goals', 'attributes', 'criteria' or 'effects' in the MCA literature. But Chankong and Haimes (1983, p. 9) reserve the term 'attribute' to define the measurable quantity that reflects the degree of achievement of a particular objective.

An illustrative example of a 'socio-economic analysis' appears in investment guidelines published by the Victorian Department of Treasury and Finance (1996, section 7.5, p. 10). Table 13.2 is a slightly truncated version of this. The table refers to the selected impacts of a hypothetical proposal for a new access road to a new shopping centre. While not specifically described as a goals achievement matrix, table 13.2 exhibits the major characteristics of the GAM method. Each 'impact' is given a score (in this case between -4 and +4), and the total score for each type of impact is weighted relative to other impacts.

The aggregate score of all socio-economic impacts in table 13.2 therefore can be characterised as an additive model, for each of the three options shown. Each impact is valued on the basis of a score from +4 to -4 (see note to table 13.2), irrespective of the original metric used, and the numerical coefficients are the weights attached to each variable by the analyst:

Score (net benefit) = 0.25 NPV + 0.1 Noise + 0.2 Pollution + 0.2 Visual + 0.25 Policy

This characterisation implies that variables (impacts) such as 'Noise' can be expressed in negative values. By implication, the NPV excludes consideration of the other variables in the equation, like 'Pollution'.

Identifying 'impacts'

Benefit-cost analysis employs a reasonably well established methodology in specifying and estimating various effects or impacts of a policy proposal on the community. By contrast, the choice of impacts to be evaluated in the GAM approach appears to be more arbitrary, because it is not based on an established analytical framework.

One tenet of BCA is that impacts are considered from the perspective of 'consumer sovereignty'. Multi-criteria analysis, on the other hand, tends to select and weight the impacts to be analysed on the basis of judgements made by planners, analysts or other decision-makers.

An example is that of someone catching a bus. A BCA analyst would normally evaluate consumption of bus transport on the basis of the consumer's monetary valuation of the service, whether expressed in stated form (such as in a survey of willingness-to-pay), or via revealed preference (the bus fare paid).

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TABLE 13.2 ILLUSTRATIVE EXAMPLE OF SOCIO-ECONOMIC ANALYSIS

Type of Impact	Impact	Option 1 (Base case)	Option 2	Option 3
Quantifiable in Monetary Terms	Expected Economic NPV Score Weighted score (25%)	0 0 0	\$150 2 0.50	\$300 4 1.00
	Increase in noise levels along new road (averaged)	10dB	30dB	60dB
	Score	0	-1	-4
	Weighted score (10%)	0	-0.10	-0.40
Quantifiable in Physical Units	Decrease in pollution (gases) to local homes (averaged)	0%	8%	5%
	Score	0	+3	+2
	Weighted score (20%)	0	0.60	0.40
	Aesthetic improvement to local area	No change	Some new greenery etc.	Significant planting of trees etc.
	Score	0	+1	+3
	Weighted score (20%)	0	0.40	0.60
Unquantifiable	Consistency with Government's May 1995 neighbourhood policy	Does not address May 1995 statement, etc.	Addresses May 1995 statement in full, etc.	Addresses items 2&3 of May 1995 statement, etc.
	Score	0	+4	+2
	Weighted score (25%)	0	1.00	0.50
Aggregate score of all socio-economic impacts (100%)		0	2.4	2.1

Note 1. The 'recommended' scoring scale runs from +4, through 0 to -4 as 'very much better (than the base case), much better, moderately better, little better, no change, little worse, moderately worse, much worse, very much worse'.

Source Victorian Department of Treasury and Finance (1996, section 7.5, p. 10).

An MCA analyst could also choose to study this impact, but the weights employed could mean that the contribution of the bus service relative to other impacts in the bottom-line result bears little relation to consumers' valuations. In addition, the MCA analyst could include any one of an infinite number of other impacts which people may or may not value. 'Decentralisation', for example, could be specified as an objective, without evidence that anyone seriously values it to the point where they are willing to forgo resources to promote it.

The problem lies in the apparent lack of generally accepted guiding principles in the choice of impacts for an MCA. The absence of established principles means that different MCA analysts are unlikely to reach consistent conclusions about a policy measure. However, the Resource Assessment Commission (RAC 1992, pp. 17–18) lists a number of desirable conditions and criteria, and Chankong and Haimes (1983, ch. 1) discuss related issues in some detail.

Impacts are sometimes chosen in MCA on the basis of ease of measurement (RAC, 1992, p. 15). Care needs to be taken because it is possible to specify a greater number of particular impacts or attributes merely because of the availability of data. One consequence of this could be that the particular impact associated with a large number of readily measurable attributes would gain a disproportionately high degree of relative importance.

Another example is the illustrative analysis in table 13.2, which could validly have included ease of pedestrian or bicycle access. In contrast, a study by Smith, Taylor and Basile (1989) focused on vehicular movement and its relationship to pedestrian access in Kuranda, north Queensland. But it included no specific pollution variables.

A study of the performance of stations in Brisbane's suburban railway network, reported by Smith and Taylor (1991), is interesting. It used 10 criteria of performance, including the population living in the station catchment area, and magnets such as shopping centres and schools, and availability of nearby car parking. The aim was to identify the 'worst performing' stations, with a view to closing them down. It is curious, however, that no attempt appears to have been made to use the obvious criterion of number of passengers actually using the station (or even a proxy such as number of tickets sold if passenger data were unavailable).

Another consequence of the lack of a framework for choosing impacts in MCA could be double counting. In table 13.2, for example, double counting might occur if the 'Government's May 1995 neighbourhood policy statement' included impacts already taken into

account elsewhere in the table, such as noise levels. BCA tends to avoid (but in practice not always successfully: see chapter 10) problems of double counting, because impacts are evaluated as closely as possible to their point of initial incidence.

Scoring

A first-best approach to assigning values to the effects of a policy measure is to estimate monetary values, as in BCA. Where full valuations are not considered feasible, or would be too expensive, the effects can be listed and analysed in terms of physical or other units. This approach provides information in a transparent manner to decision-makers.

It might be argued, however, that some decision-makers require (in fact, demand) a single number from the analyst.

One possibility is to express all effects within a uniform scale. This approach has been used in table 13.2, where each effect (impact) is scored on a scale that has a range of -4 to +4. Although the use of scaling converts all impacts to a common range of values, it preserves relativities for each effect under different options. In the case of 'Expected Economic NPV' in table 13.2, for example, option 2 (\$150) receives a value of +2, half that of option 3 (\$300) which is scored as a +4. This approach is termed a 'ratio scale'⁹⁵.

While scaling is not as good as using the original money-value data, because of the loss of transparency, it is superior to the use of ordinal ranking. Use of ranking in table 13.2 would have resulted in scores of 1, 2, and 3 respectively for the NPV values under options 1, 2, and 3. The result would be a greater loss of information in terms of relative sizes of NPV values than was the case when ratio scaling was used. A set of NPVs of \$0, \$150, and \$151 would receive the same score of 1, 2, 3 as the set \$0, \$150, and \$300. In other words, ranked scores may inform the decision-maker that one NPV is larger than another, but not how much larger.

In studies where a mixture of different scales — including money values, counts such as 'number employed', ranking from most to least desirable, etc. — are used, various forms of standardisation may need to be applied to ensure numerical additivity. The Resource Assessment Commission (RAC 1992, appendix II) reviews some of



⁹⁵ In cases where the ratios are not exact integers it is important that the values are not 'rounded off'.

the more common procedures and the potential biases that may be involved.

But the use of numerical scores cannot overcome the difficulty that the damage caused by noise or pollution cannot be estimated reliably. Thus there is some danger of decision-makers gaining the false impression that the analyst has managed somehow to estimate *objective* values. Further, where scores expressed in monetary values are combined with scores in non-monetary values, then the 'nonmoney' variables attract an implicit 'money' value.

Distorted valuations can occur where variables measured in physical units, such as decibels of noise or parts per million of atmospheric pollution, are converted to cardinal or ordinal scales. On a scale of -4 to +4, for example, with a linear transformation between decibels and units of the scale, the difference between 3 and 4 represents a far greater increase in discomfort to people than the increase from 0 to 1. Similarly, the health costs of pollution, beyond a certain threshold, are likely to rise proportionately more than with the number of parts per million.

Unless appropriate transformation functions are used to map physical units onto the scales employed for the MCA, environmental problems such as noise and pollution could be over- or under-represented: in effect, the opposite of the intention of those using the GAM method to give appropriate recognition to variables that are not easily expressed in money terms.

Weighting — the Achilles' heel of the GAM approach

Weights are of critical importance because, like prices, they establish the relative importance of the impacts. If the scores allocated to various impacts were to be aggregated without weighting, all impacts would, by implication, be considered to be equally important. This is clearly not realistic.

In practice, specifying weights is probably the most arbitrary aspect of GAM analysis. It is, therefore, essential that the process be as transparent as possible: to ensure that the analyst's methodology can be fully assessed and understood.

National interests or community preferences can be reflected in GAM analysis by seeking the views of elected representatives, rather than using weights determined by analysts or public servants. However, even governments elected to make judgements about community values and national interests need to be able to defend these decisions for consistency and derivation from some evidence.

Also, busy government ministers would be unlikely, at the national or State level, to be able to take decisions on weights used for more than a limited number of projects.

Obtaining weights by consulting local communities offers an alternative, but is likely to result in bias towards local interests. In the construction of an interstate road, for example, weights could be set to favour local traffic or pedestrians, to the disadvantage of through-traffic. The result is likely to be sub-optimal decision-making from the broader, national perspective.

The weights used in table 13.2 are based on the view of the Victorian Department of Treasury and Finance (1996, section 8.2.1, p. 3, table 8.1) that, where commercial returns are sought from a project, the result of the financial analysis (expressed as an NPV) should have a higher weighting. The hypothetical project in table 13.2 is a 'service' project rather than one designed to generate revenue; so the NPV receives a weight of only 25 per cent, and the other variables are valued commensurately more highly at 75 per cent. No justification is provided for this choice of weights, or for the apparent bias towards obtaining a 'desirable' or predetermined result.

Indeed, the issue is further confused by the statement of the Victorian Department of Treasury and Finance (1996 p. 4, section 2.2) that 'with experience, different sets of weights might be applied by different Departments for a particular investment category'. Use of different weights for similar investments at a given point in time would do little to dispel the impression of arbitrariness that is often associated with the issue of weighting in MCA.

Nor is the impression of arbitrariness fully dispelled by the approach taken by some analysts to the sequence involved in choosing weights. The Victorian Department of Treasury and Finance (1996, section 7.2, p. 4) sensibly specifies that:

To ensure that the judgement of the relative importance of all socioeconomic impacts is not influenced by the results of their measurement and analysis, the judgement about relative weighting should be made after all those impacts have been identified but prior to their measurement and analysis.

In contrast, the RAC (1992, pp. 24–25) suggested that decisionmakers should be able to change weights as part of an interactive process with the analyst. Perry and Dillon (1978) mount a similar argument in the case where deterministic models are not feasible because of multiple objectives and the uncertainty of effects.



The weighting system ensures that adding further, even closely related, attributes produces no double counting distortions and bestows no contrived advantage regardless of how much the attributes are correlated.

Several pages on, however, he claims that the system of 'doubleweighting' used in the software developed for the report 'minimises' the impact of double counting (Thoresen 1998, p. 11). Unfortunately no explanation is offered for either of these views. (Informal discussions between BTE researchers and proponents of MCA techniques suggest that such views may be based somehow on the

BOX 13.1 WEIGHTS AND SCORING

Weighting can be illustrated as in the diagram below.

Impacts are scored on scales of equal intervals to provide a consistent metric. The application of different weights to the scale for each impact results in different levels of compression: more compressed scales imply relatively less important impacts.

It seems sensible to score impacts on identical scales, using the whole range of the scale, and introduce the weightings afterward. Otherwise, differences in scoring scales introduce one set of weights implicitly, and a second set of weights is imposed on top; making it hard to see the true overall weights.

Impact	Scoring Scale	Weight applied to impact	Weighted scoring scale
Net present value		0.5	
Employment		0.1	-
Pollution		0.2	
Noise		0.2	
Sum		1.0	

ILLUSTRATION OF EFFECT OF WEIGHTING SCORING SCALES



fact that weights are always set to add up to 1.00, or 100 per cent.) Thoresen does point out, however, that 'the technical literature is remarkably vague' about the importance and impact of double counting.

A judicious choice of weights might be used to reduce the relative importance of impacts which involve double counting. But it is likely that any such contrived application of weights will distort the relative importance of other impacts. Whether there is a net benefit to be gained from distorting a weighting system merely to reduce the effect of double counting is questionable. A more direct solution would be to eliminate the double counting itself.

In any case, adjusting weights cannot eliminate any errors caused by double counting.

THE PROBLEM OF TIME

Benefit-cost analysis relies on the concept of net present value to permit comparisons of costs and benefits that accrue at different points in time. This is particularly important in the case of transport infrastructure, most of which is relatively long-lived.

The treatment of time in MCA seems to have been given scant attention in the literature. In particular, it is not clear how criteria that relate to future effects (such as environmental damage) can be summed with effects that refer to the present (such as the net present value of costs and benefits that can be expressed in monetary terms).

Perry and Dillon (1978, p. 138) suggest the use of 'time-indexed attributes'. If a GAM analysis specified three impacts over a period of four years, for example, then each impact would need to be scored four times. By weighting impacts differentially in different years (for example, with lower weights where impacts occur further into the future) it is allegedly possible to capture the inter-period preferences of decision-makers.

An MCA study of railway station performance reported by Smith and Taylor (1991) appears not to have addressed the problem of time at all. One criterion used in the study was the population within the catchment area (800 metres radius) of a railway station in 1986. Growth (or decline) in the catchment population over the period 1981–86 was also included as an indicator of future population growth in the area. Both the existing population and its expected growth rate were given equal weights in the analysis. It is difficult to reconcile the use of future population growth with the stated



analytical objective of assessing the *current performance* of each station. Nor is it clear why current and future population levels should be used simultaneously, or why they should be given the same value.

ASSESSMENT

Lack of an established analytical framework or uniform approach to MCA makes rigorous assessment difficult.

Based loosely on BCA techniques, the PBS method seeks merely to ascertain how much an investment proposal will contribute to the wellbeing (or losses) of the socio-economic groups affected. It is important to appreciate that Lichfield intended the PBS method to supplement, rather than replace, benefit-cost analysis. Indeed, he recently reiterated his view:

While MCA is a powerful tool for many problems, and can supplement CBA ... we should not pursue that path as a substitute for cost-benefit analysis ... what seems to have been ignored by MCA protagonists is the fact that adaptations of CBA have been sought over the years, so that continuing to attack the 'traditional cost-benefit analysis' is creating something of an Aunt Sally [a metaphorical object of unreasonable attack]. (Lichfield 1993, p. 206).

While it is true that the application of BCA techniques *in practice* often leaves much to be desired, the GAM *methodology* suffers seriously from a high degree of subjectivity in its key elements of scoring and setting weights. A good deal of intellectual effort seems to have been expended on developing mathematically sophisticated assessment procedures (see, for example, Chankong & Haimes 1983, and Nelson, English, Loxton & Andrews 1998). Nevertheless, no amount of elegant mathematical superstructure can alter the fact that the underlying scoring methods and the setting of weights are highly subjective.

For some reason, there appears to have been little discussion of a particularly critical limitation of the GAM technique: that it cannot be used at a national level to compare projects of different types.

For example, it would be virtually impossible to compare, and therefore to choose between, a project to build a road and one to build a hospital. Because the impacts of a road project (travel time, environmental effects, etc.) differ so markedly from potential impacts of a hospital (improvement in health, bed-waiting times, etc.) and are measured in different units — rather than the unifying metric of money values — comparisons would be almost meaningless. Without



resort to the money metric used in BCA, it is virtually impossible to say how many roads are worth one hospital.

In other words, the GAM technique is effectively limited to comparing alternatives for implementing a single project, such as different routes for a road. It therefore has more in common with costeffectiveness studies (where a single criterion is used), which presuppose that a project should proceed. So its role is limited to determining only the 'best' means of implementation. Because it cannot determine the opportunity cost (in terms of net benefit forgone) of alternatives in other sectors of the economy, its utility at a 'whole-of-government' level is negligible.

Legislative provisions may require the use of MCA techniques rather than BCA. Nelson, English, Loxton & Andrews Pty Ltd (1998, appendix B) points out that the Queensland Government requires the application of 41 selection criteria and 22 evaluation criteria to transport projects, including economic development, trade development, social justice, safety, and regional development.

However, while mandatory criteria may be imposed on the analyst, they can hold dangers of their own. For example, Marshment (1993, p. 339) examines the practice of the Federal Transit Administration (FTA) of using a (single criterion) cost-effectiveness index rather than BCA in assessing rail investment projects.⁹⁶ In general he finds travel time savings produced by rail transit are less than the costs of investment. However, use of BCA in this situation would put 'the FTA at risk of not aiding in the advancement of any projects. This is contrary to the mandate from Congress to find and fund cost-effective projects'.

Less justifiable is the approach taken in the Integrated Transport Study by the South and West London Transport Conference (SWELTRAC). The study group comprised a partnership of 11 local authorities, bus and train operators and Railtrack, but not, apparently, representatives of motorists. The aim of the study was 'to evaluate local transport schemes and develop a strategy for improving public transport and *reducing car dependency* in south and west London' (emphasis added).



⁹⁶ The index is the cost per new rider which results from a project. The numerator equals operating and construction costs (annualised) minus the value of travel time savings for existing riders.

Given these circumstances, and an admitted aversion to 'traditional benefit-cost analysis', it is hardly surprising that Michele Dix, 'director of consultant Halcrow Fox and a long-time advocate of the GAM technique', is quoted by Dunning (1997, p. 12) as saying:

Conventional assessment methodologies were found lacking, particularly when evaluating traffic restraint and bus priority measures that would adversely affect private car users *and result in a negative COBA* [Cost Benefit Analysis] value (emphasis added).

In other words, use of BCA might have given the 'wrong' results. One wonders why the sponsors of the study did not simply adopt their preferred solution and avoid the expense of conducting the study.

Whatever the reason for using MCA for evaluations, good policy formulation still requires that decision-makers have available to them information on the net cost or benefit to the nation. Even if unviable projects are adopted on legislative, equity or other grounds, it should be made clear what cost will be imposed on the overall community as a result of such decisions. This information can be provided only through a properly conducted BCA.

IN SUMMARY

- Lack of an established theoretical framework for multi-criteria analysis hinders definitive comment. The BTE was unsuccessful in its informal approaches to personnel in various State road authorities for a 'live specimen' of an MCA. However, most Australian MCA studies appear to use the goals achievement matrix approach.
- The GAM approach is based on 'scoring' goals (or 'impacts') that are considered relevant to the evaluation of a project. The results are adjusted by applying weights determined by analysts or planners.
- Despite the very considerable mathematical and statistical sophistication that has been applied to weighting and scoring systems, the underlying analytical framework remains highly arbitrary and subjective. Nor can weighting systems obviate any errors introduced by double counting where overlapping goals are included in the analysis.
- The GAM approach has limited policy relevance, because it cannot be used to compare projects in different sectors. A road project subjected to GAM analysis cannot be compared directly



to the results tabulated for a hospital project, for example, in the absence of a common metric.

• Even if a GAM analysis is used to compare different transport alternatives, a BCA is still essential if decision-makers are to be informed of the overall social cost.



APPENDIX I

MONOPOLY AND THE VALUE OF BUSINESS TRAVEL TIME SAVINGS

Savings in travel time reduce the crew requirements for some trucking operation by one worker. As a result, someone who would have driven a truck does other work instead. The benefit to society arises from the worker's output in the alternative employment.

Suppose that the alternative employer is an unregulated monopolist (a company) that operates for profit. The monopolist does not pricediscriminate between customers. (Prices could vary between customers, however, in line with real differences in the cost of supply.) The monopolist charges each customer a price that exceeds what cost considerations would warrant. The excess of price over the marginal cost is the monopoly price mark-up.

The output of the additional worker benefits both the monopolist and its customers. The worker's labour adds to the monopolist's output. But to induce customers to buy the extra output, the monopolist must reduce its price. Hence the customers benefit. The monopolist benefits from the additional output as well. Although the price reduction cuts into revenue, the additional units sold increase it. Overall, revenue increases — otherwise, the monopolist would not have hired the additional worker.

The benefit to the employer could be roughly measured by the cost of employing a truck driver. The logic for this approximation, explained in box 4.3, is independent of whether the employer is a monopolist. It would also apply when the employer faces perfect competition or, more realistically, something intermediate. The practicality of this approximation has made it standard in transport BCA.

Since the cost of employing a truck driver approximates the benefit to the monopolist alone, the total benefit to society, including that to customers, is somewhat larger. To estimate the total benefit, one would have to add the benefit to the customers to the cost of



employing a truck driver. One could show that the benefit to the customers would approximately equal the monopoly price mark-up multiplied by the output gain from the additional worker.⁹⁷

What if the alternative employer faces perfect competition for its product, rather than having a monopoly?

In certain respects, the analysis remains the same. In either situation, employing the additional worker would increase the employer's revenue; and the revenue gain could be approximated by the cost of employing a truck driver.

But there is a key difference in how the employer would calculate the revenue gain. The monopolist would deduct the loss in revenue from having to reduce its price. The competitive firm would not make this adjustment. As one of many tiny producers in the same industry, it would ignore the effect of increasing its own production on the market price. In reality, the market price would decline, reducing industry revenue. But the firm that increased supply would absorb only a tiny fraction of this revenue loss — small enough for the firm to ignore. Other firms in the industry would absorb the rest.

In line with this, perfect competition permits simpler measures of benefit than does monopoly. The aim is to measure the total benefit from the additional worker's output. Under monopoly, one needs to sum the benefits to the employer — as approximated by the cost of employing a truck driver — and the benefits to the customers.

Under perfect competition, one does not have to add the benefits to the customers. The benefit to the employer — again, proxied by the cost of a truck driver — will suffice. True, the benefit to the employer does not reflect the gains to the customers from lower prices. But neither does it reflect the revenue loss to industry from lower prices. (Recall that nearly all of the revenue loss falls on other producers in the same industry, rather than on the employer of the additional worker.) The omitted gain to the customers cancels out the omitted loss to the industry.

97 See Mohring and Harwitz (1962, p. 192). They calculate the monopoly price mark-up at the 'old' price, before the monopolist increases output. The use of the 'old' price introduces an element of approximation into their equation (1). The element of approximation would disappear, were the equation recast in calculus.



APPENDIX II

THE ROLE FOR NATIONAL ECONOMIC MODELS: RELATED EVIDENCE

EVIDENCE FROM MODELS OF HYPOTHETICAL ECONOMIES

Several studies have simulated improvements to transport using models of hypothetical economies. They throw light on two key questions about benefit measurement: Does information on transport outcomes suffice? Does partial equilibrium analysis suffice?

Does information on transport outcomes suffice? Perfectly efficient economies

For a start, consider the case of a perfectly efficient economy. Absent from such an economy are inefficiencies arising from various sources, including lack of competition, distortionary taxes and unpriced externalities (such as pollution from motor vehicles).

For such an economy, the studies indicate that total benefit from a transport investment can be closely approximated with information on transport outcomes alone.

Hussain (1990) and Morisugi (1987) are among the studies reaching this conclusion. Morisugi models an actual economy, Japan, though in such simplified terms that the economy being described verges on the hypothetical. For this reason, it is discussed in this section, rather than with models of actual economies.

Hussain calculated the benefits from road investments, within a three-region economic model. Each region produces a single good, and trades its product with the other regions. In all markets, including labour markets, price adjustments are assumed to keep supply always equal to demand. (The simultaneous balance of supply and demand forces across all markets defines a 'general equilibrium', a term that describes this type of economic model.) Although the model thus excludes unemployment, it allows road investments to affect aggregate employment through changes in labour supply and demand.



Hussain compared alternative measures of benefit, for various levels of reduction in road freight cost. One of the measures was the change in transport consumer surplus (CTCS), a standard measure of benefit that is based on transport outcomes alone (as described in chapter 2).

The other measure was the equivalent variation in income (EV) described in chapter 1. The EV is the precise measure of benefit in the model, whereas the CTCS is an approximation. Calculation of the EV requires information on outcomes throughout the economy, including effects on wage levels. In the model, reductions in the cost of road freight lead to a general increase in real wages. The wage increase, in turn, prompts workers to supply more labour, with a concomitant loss of leisure time. In calculating the equivalent variation, Hussain deducted the money value to workers of their lost leisure.

The findings reveal only minor differences between the CTCS and the $\ensuremath{\mathsf{EV}}\xspace.$

When the economy is assumed to be perfectly efficient, the EV slightly exceeds the CTCS. In other words, the CTCS slightly understates the true benefits of the road improvements. The size of the error varies with the assumed reduction in freight cost, which ranges from 15 to 50 per cent. For a 15 per cent reduction in freight cost, the error is a mere 0.4 per cent. For larger reductions, the error is even smaller.

Morisugi (1987) also used a general equilibrium model, although one lacking a regional dimension. The aim of the modelling was to estimate the total benefit from formation of Japanese expressways between 1964 and 1981. Morisugi compared a precise measure of total benefit, the EV, with an approximation based on transport outcomes alone. The approximation was a variant of the CTCS.

Like Hussain, Morisugi found that transport outcomes could yield a close approximation to total benefit. The CTCS-variant was within one per cent of the true benefit, as measured by the EV. The error, such as it was, ran in the opposite direction to that in Hussain's analysis, and to that often claimed by BCA critics. Restricting the focus to transport outcomes, as in conventional BCA, caused overestimation of benefits.

Bos and Koyck (1961) wrongly reported that the CTCS understates benefits. For a reduction in road freight costs in a three-region economy, they found the benefit to be much larger than the CTCS —



in one scenario, over seven times larger.⁹⁸ But their measure of benefit — the increase in real national product (GDP) — was biased upward. Real GDP does not reflect the costs of increases in aggregate employment (chapter 9). Although Bos and Koyck do not model employment, their scenario seems to imply that aggregate employment increases when road freight costs decline. (More generally, it is hard to know exactly what is going on in their scenario, because their model is underspecified.)

Tinbergen (1957) also focused on the national output gains from an improvement in road freight transport. However, he acknowledged that there is a question as to whether national output 'is the correct measuring rod of welfare'. Bos and Koyck based their modelling on Tinbergen's work, but appear to have disregarded this caveat.

Taken together, the various studies suggest that restricting the focus to transport outcomes will introduce errors into benefit measurement that are small and ambiguous in direction, *at least in an economy that is highly efficient*.

For an intuitive understanding of this finding, readers may review the discussion of the CTCS in chapters 2 and 3. Of particular relevance is the discussion in chapter 2 of the induced traffic benefit, which forms part of the CTCS. Although based on transport outcomes alone, it can capture benefits from various responses to improved transport, such as expansion of regional industries, or changes to inventory and warehousing practices.

Economies with inefficiencies

Measuring the benefits from transport improvements is more difficult for less efficient economies. Information on transport outcomes may or may not suffice for a close approximation.

Hussain (1990) concluded that the approximation was no longer good once his model incorporated inefficiencies. Each of several sources of inefficiency entered the model in a separate experiment. One of the sources was imperfect competition. The others were three distortionary taxes: on wages, consumption, and intermediate goods (used as inputs to production). The rate of each tax was 25 per cent. In each experiment, the CTCS understated the true benefit, though by 5 per cent at most.



⁹⁸ Bos and Koyck do not refer to the CTCS by name. However, the measure described in their penultimate paragraph is the 'rule of half' approximation to the CTCS.

Venables and Gasiorek (1998), discussed in chapter 8, also found information on transport outcomes to be inadequate. In their model of a hypothetical economy, imperfect competition causes inefficiencies. They report that measures based on transport outcomes alone understate the benefits of a transport improvement. The errors were typically between 30 and 50 per cent.

These findings reveal little about the performance of conventional benefit measures in practice.

In large part, this is because the models are hypothetical. Depending on the data one inputs to such models, imperfections in competition could be either important or trivial. Neither study — Hussain or Venables and Gasiorek — provides evidence that its data are in any sense representative of an actual economy. Indeed, Venables and Gasiorek caution that their data are 'made up'.

In addition, the findings present difficulties in interpretation.

Hussain does not explain the mechanisms in his model that drive the results. It would be interesting to know, for example, how much of the benefit understatement stems from effects on aggregate employment.

Venables and Gasiorek explain their results incompletely. They argue that improvements in transport encourage competing firms to locate close together, and that this benefits society by strengthening competition. But improvements in transport do not necessarily have this effect — they might also cause competing firms to disperse (see chapter 8).

Economies with dynamics: A caveat

The above-discussed models of hypothetical economies are comparative static (see glossary). They do not include the effects of a transport improvement on dynamic processes such as investment. The existence of such effects reduces the adequacy of transport information for measuring benefits.

Does partial equilibrium analysis suffice?

Kanemoto and Mera (1985) addressed the question of the adequacy of partial equilibrium analysis. For a general reduction in freight costs within a two-region economy, they compared partial and general equilibrium measures of benefit. Both measures are based on the CTCS, and hence on transport outcomes alone. However, the general equilibrium (GE) measure uses actual transport outcomes, whereas



the partial equilibrium (PE) measure uses transport outcomes exclusive of certain effects.

Specifically, the measures used different demand curves for freight transport. In the PE measure, the demand curve was predicated on certain variables being exogenous (unaffected by the reduction in freight cost). The exogenous variables are regional incomes and producer prices net of freight costs. In the GE measure, these variables are endogenous; hence the demand curve for freight transport holds nothing artificially 'fixed'.

Kanemoto and Mera show that the PE measure could be either larger or smaller than the GE measure.

The assumed exogeneity of regional incomes, taken on its own, makes the PE measure the smaller of the two. A uniform reduction in freight costs would increase regional incomes. With their incomes higher, people in each region would demand more imports from the other region. As a result, freight traffic would increase. The GE measure includes this component of induced traffic, whereas the PE measure does not. So the benefit from induced traffic, which forms part of the CTCS, is smaller in the PE measure.

The assumed exogeneity of producer prices, on the other hand, tends to make the PE measure larger than the GE measure. Again, the explanation lies in the induced traffic. The reduction in freight costs gives rise to price effects that dampen the amount of induced traffic. The GE measure takes account of the dampening effects, whereas the PE measure does not.

Why would the changes in producer prices reduce the amount of induced traffic? Kanemoto and Mera offer a highly technical explanation. However, the mechanism is basically the same as in Chapter 9's example of port charges (example C). As was explained, an inland railway between Brisbane and Melbourne might lead to lower port charges at Newcastle. The lower charges, in turn, would reduce the amount of traffic on the inland railway.

Welfare economics, of which transport BCA forms part, provides many similar examples of dampening effects from price changes. The existence of such effects is called the 'Le Chatelier principle'. Brannlund and Kristrom (1996) appeal to this principle in comparing PE and GE measures of the social costs of taxes. They observe, correctly, that the principle implies the PE measure being larger than the GE measure.
EVIDENCE FROM MODELLING OF TARIFF REFORMS

Economists have estimated the welfare effects of countless policies and programs besides transport investments. Debate about the need for national economic models cuts across many areas of application.

Simpler, and in some ways narrower, frameworks are often used. The simpler frameworks have much in common with conventional transport BCA. Instead of estimating the outcomes throughout the economy, they focus on outcomes in the most directly affected sectors. Often, they are called 'partial equilibrium' analyses (which is sometimes a misnomer; see chapter 9).

National economic models hold the promise of sharper estimates of welfare effects, but they are also more cumbersome. A key question is whether the added precision is worth the additional modelling effort. Because the question is the same across many areas of application, evidence from areas outside transport can be relevant to transport BCA.

Dixon et al. (1997a; 1997b) have stimulated debate over this question with recent studies using the MONASH model. The studies emanated from Industry Commission inquiries into the automotive industry and the textiles, clothing and footwear (TCF) industries. Reductions in tariff protection for these industries were simulated, and welfare gains to Australians estimated from the simulation results. The measure of Australian welfare was real private consumption expenditure. (Real public consumption expenditure was exogenous.) The estimate of welfare gain is 'general equilibrium' (GE), since MONASH is a GE model of the Australian economy.

For comparison, Dixon et al. derived from the simulation results what they called a 'partial equilibrium' (PE) estimate of welfare gain. The information underpinning this estimate pertains only to the relevant import markets. Apart from the assumed reduction in tariff rates, the only information that is needed is the increase in import volumes that the tariff cut would induce.

The equivalent in transport BCA is the induced traffic benefit as conventionally calculated. The information that is required pertains only to the relevant transport markets: the decline in transport cost and the induced increase in traffic. Indeed, the formula is basically the same as in PE calculation for tariff cuts, apart from the variables having different names. The formula, known in transport BCA as the 'rule of half', calculates a triangular area. (See chapter 2; figure 1 and related discussion.) Similarly, the PE measure of welfare gain



from a tariff reduction is often referred to as the 'welfare triangle' (or 'Harberger triangle', after a pioneering welfare economist.)

Although Dixon et al. used the MONASH model, one could obtain a similar estimate of the induced increase in import volumes — and hence, a similar PE estimate of welfare gain — without a national economic model. Murphy (1997), for example, used a model of the TCF sector to simulate the same reductions to the sector's tariff protection as did Dixon et al. (1997b). Both studies give a PE estimate of welfare gain of about \$50 million in 1995–96 prices (Murphy 1997, p. 38).⁹⁹ The similarity is not entirely coincidental: Murphy's model represents the TCF sector in much the same way as MONASH, except that it disaggregates the sector more finely.

The comparison that Dixon et al. performed between their PE and GE estimates is one test of the MONASH model's value for analysing tariff cuts. The PE estimate is also derivable from a simpler framework. So if the GE estimate turned out to have been similar, then use of the MONASH model would have revealed little about the welfare effect that could not have been learned more easily. On the other hand, a significant difference between the estimates would vindicate the model's use.

As it turned out, the PE estimates from Dixon et al. were only 35 to 40 per cent as large as their GE estimates. The authors concluded that 'partial equilibrium analysis is an inadequate basis for assessing the GDP and welfare gains associated with reduction in tariffs' (Dixon et al. 1997a, p. 46; 1997b, p. 57). The clear implication is that estimation of the welfare gains requires a national economic model like MONASH.

Dixon et al. also explained the difference between PE and GE estimates within a detailed accounting framework. They decomposed the difference into quantitative contributions from various factors that the PE framework does not capture (even indirectly). Among these factors are the effects of the tariff reductions on export prices and on revenues from commodity taxes other than the tariff cut. The factors are generally easy to understand. (Commodity tax revenues enter the picture in much the same way as in evaluations of transport investments; see chapter 7).



⁹⁹ In light of this, Dixon et al's use of 'partial equilibrium' can be allowed. Strictly speaking, none of their estimates of welfare gain are 'partial equilibrium', since they are all derived from MONASH, a general equilibrium model. But the estimates thus labelled are similar to those from a PE model. Murphy used a model that qualifies as PE because it represents only the tariff-protected sector. The model was F-4, developed by Econtech.

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The elements of the framework that are not so easy to understand are certain 'share effects'. These effects account for much of the difference between the PE and GE estimates of welfare gains. Although the BTE has been unable to spot any errors in the accounting framework, it is difficult to relate the 'share effects' to economic theory, as has also been noted by Murphy (1997). Dixon et al. do not supply an intuitive explanation. Elsewhere, it has been observed that the share effects arise from the dynamics in the MONASH model, and thus would be absent from a model that is comparative static (Dixon and Rimmer 1998, p. 51).

Dixon and Rimmer (1998) reworked the analysis of motor vehicle tariff cuts in Dixon et al. (1997a). After correction of an error in the earlier work, the GE estimate of welfare gain was slightly negative, and hence smaller than the (positive) PE estimate. The error was in the modelling of a miscellaneous category of production costs, as explained in chapter 9 (box 9.4).

BTE discussed with one of the authors, Professor Dixon, the implications of this research for transport BCA (P. B. Dixon, pers. comm., 17 July 1998). It was put to him that transport BCA is normally 'partial equilibrium', as he has used the term. (Welfare effects are measured from outcomes in the directly affected sectors, transport and construction, rather than from outcomes throughout the economy.) The BTE asked whether such analysis is adequate for estimating welfare effects.

Professor Dixon recognised that the choice of framework — PE or GE — is a general issue in welfare economics, including in the evaluation of transport investments. He agreed that the PE estimates of welfare effects could be either larger or smaller than GE estimates.

More controversially, Professor Dixon argued that the differences between PE and GE estimates can often be substantial, emphasising the potential for 'share effects' to contribute to these differences. Accordingly, he rejected the BTE's suggestion that PE analysis will generally be adequate for estimating the welfare effects of transport investments. He saw a significant role for general equilibrium models, such as MONASH, in estimating these effects.

Only applications to transport investments can determine whether GE models can play such a role and, if so, for what sorts of investments. The BTE has reviewed the relevant evidence (chapter 9), including that from models with labels other than 'general equilibrium'. But it has found no reliable evidence that national economic models can improve significantly on PE estimates of welfare gains.



GLOSSARY

Aggregate demand The sum of all demands for an economy's output. It can be split into categories of 'final' demand: the demands for investment goods and stocks, for public and private consumption, and the net demand for exports (net of imports).

Benefit-cost analysis (BCA) An analysis of the benefits and costs to society of some action. It aims at valuing benefits and costs in money terms and producing a summary measure of net benefit. To emphasise the societal perspective, BCA is sometimes called *social* benefit-cost analysis. Society refers to a defined community, usually the whole nation.

Comparative static Economic analyses that are non-**dynamic** are comparative static. A common mistake is to equate comparative static with single-period analysis. Morisugi (1995), discussed in appendix II, is an example of a multi-period analysis that is nevertheless comparative static (for lack of intertemporal relationships between **endogenous** variables).

Consumer surplus A money measure that equals a defined area under a demand curve. The area is bounded by the vertical axis (which measures price) and, from below, by the purchase price. The interpretation of this measure and its value for economic analysis have been subjects of debate (see, for example, Slesnick 1998). BCAs often use consumer surplus to measure the benefits to society from an improvement in transport—most often, they estimate the *change* in transport consumer surplus (chapter 2). See also producer surplus.

Cost-effectiveness analysis attempts to determine the least-cost means of achieving a given objective. It does not attempt to value the benefits of meeting the objective.

Cost-benefit analysis (CBA) Another term for benefit-cost analysis.

Cross docking An arrangement in which 'cargoes are transported by road or rail to a warehouse, then transferred direct across the loading dock to local delivery vehicles, without being stored in the warehouse shelves.' (BTCE 1997b, p. 89)



Current account balance A nation's current account balance has three components, each measured in the nation's currency: the trade balance (exports minus imports of goods and services); net income from foreigners (including, for example, interest received from foreigners minus interest paid to foreigners); and net unrequited transfers (such as net payments of foreign aid and pension income). Australia's current account balance has been chronically in deficit, with net income from foreigners being negative.

Demand curve For a good or service, the quantity demanded depends on its price. The demand curve depicts this relationship on a graph. Factors other than price which influence demand are held constant for a given demand curve.

Discount rate It is standard in BCA to discount future benefits: to assign them a lower value than benefits that arise earlier. The discount rate is the percentage by which benefits in one period would have to increase to retain the same value, were they to arise a period later instead. At an annual discount rate of 8 per cent, for example, a dollar's benefit now counts the same as \$1.08 in benefits in a year's time.

Dynamic An economic analysis is dynamic if it includes intertemporal relationships between endogenous variables. The most commonly included are capital accumulation equations, which relate stocks of capital in one period to past levels of investment or saving. However, capital accumulation equations alone do not qualify an analysis as dynamic. The levels of investment or saving would have to be endogenous variables: explained by the analysis rather than exogenous (taken as given).

Econometrics The development and use of statistical models to describe economic relationships. Often misunderstood by non-economists to refer to all mathematical modelling of economic relationships. Modelling can be mathematical without being statistical.

Economic efficiency An economy that is perfectly efficient leaves no unexploited opportunities to improve everybody's welfare. Landsburg (1993, chapter 8) illustrates the concept and shows that certain conditions lead to economic efficiency: competition, rationality and the existence of prices.

Elasticity A mathematical measure used in economics to describe the strength of a causal relationship between two variables. 'The elasticity of X with respect to Y equals Z'. The approximate interpretation of this statement is that a 1 per cent increase in the



variable Y causes a Z per cent increase in the variable X. The precise interpretation entails concepts from calculus: Z equals the first derivative of the natural logarithm of X with respect to the natural logarithm of Y. Strictly speaking, these interpretations relate to a 'point' elasticity, which is what economists are normally referring to with the term 'elasticity'. An 'arc' elasticity describes the effects of large changes in the influencing variable. For more on arc versus point elasticities, see IC (1994 pp. 35-36).

Endogenous The opposite of **exogenous**. An economic model solves for (explains) a variable that it treats endogenously.

Exogenous In economic models, an exogenous variable is assumed to be uninfluenced by other variables in the model. It is determined outside the model. Exogeneity is often confused with constancy over time. A national economic model may treat the nation's birth rate as exogenous, that is, uninfluenced by economic conditions which are represented in the model. However, the birth rate may be changing over time because of other factors, such as changes in the age composition of the population. The model may include forecasts of the birth rate obtained from some other source, since changes in the birth rate will affect the economy.

Externality An effect that one party has on another and that is not transmitted through market transactions. An example is noise pollution from trucks. Those driving the trucks disturb other parties such as residents near a highway. A market transaction between these parties is absent.

Economists sometimes label 'technological' an externality as defined above. Chapter 12 discusses other concepts of externalities.

Furphy (Australian slang), 'false report or rumour [f. rumours said to have come up with Furphy carts, water and sanitary carts used in [the] 1914-18 war, manufactured at foundry established by Furphy family at Shepparton, Vic.' (Turner 1984).

General equilibrium A state of the economy in which forces are in balance in all markets. In an economy with perfect competition, supply would equal demand in each market. This is the most common equilibrium condition in general equilibrium models of national economies. But some of the models use other conditions to allow for imperfect competition, especially in labour markets.

Indirect taxes are taxes assessed on producers, on the production, sale, purchase or use of goods and services. Examples are sales taxes, payroll taxes, custom duties and land taxes (ABS 1990, pp. 82, 282).

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Input-output (IO) analysis describes the production interdependencies between sectors of an economy. It offers a simplistic description of how the structure of the economy might respond to certain changes, such as an increase in export demand for a particular product. At the core of an IO analysis are tables of data for some base year. Such a table might show, for example, the total purchases by the defence industry of material and service inputs from the paper products industry (for further basic description, see IAC 1989).

Labour force The number of persons aged 15–69 who are employed or unemployed.

Law of diminishing returns refers to changes in the marginal product of an input. A thought experiment: a producer uses one more unit of labour, while holding constant the amounts of other inputs. Imagine perhaps that a farmer employs one more worker to weed a vegetable patch. The consequence will be an increase in output, the amount of which is the 'marginal product of labour'. The law of diminishing returns says that the marginal product of labour diminishes as more labour is employed. As more workers tend the vegetable patch, fewer weeds are to be found, so the gain in output from yet one more weeder declines.

Logistics '... is the management of all inbound and outbound materials, parts, supplies and finished goods. Logistics consists of the integrated management of purchasing, transportation, and storage ...' (Cavinato 1982).

Macroeconometric refers to the estimation of econometric models using macroeconomic ('whole of economy') data. Such data could include, for example, time series on real GDP, the unemployment rate, and the consumer price inflation rate. They could also include data that are subnational but still highly aggregated, such as real GDP by State.

Marginal cost is the cost of an extra unit; for example, the marginal cost of production is the cost of producing an extra unit.

Market imperfection Any characteristic of a market, such as lack of competition, that impedes economic efficiency.

Multi-criteria analysis (MCA) lacks precise definition. It refers to a loose collection of analytical frameworks that are seen as alternatives to **benefit-cost analysis**. A conventional BCA will include economic efficiency as the central criterion for evaluating a project (chapter 1). An MCA may or may not consider economic efficiency, and will often include other criteria. The versions closest to BCA retain an emphasis



on economic efficiency, but present more information on distributional outcomes – who gains and loses, and by how much – than is common in BCA. See the discussion of MCA in chapter 13.

Net benefits Benefits minus costs.

Net present value The present discounted value of a stream of net benefits over time.

Nominal exchange rate The value of one country's currency in a foreign currency, as measured by the prevailing rate of exchange.

Numeraire The unit of accounting in an economic framework. 'The money spent on that highway could have laid 300 km of railway track'. In this statement, a unit of railway track is the numeraire for costing the highway.

Partial equilibrium A state of the economy which is not a **general equilibrium**. Only some forces are in balance.

Perfect competition A market with perfect competition has many buyers and sellers, each accounting for a very small share of the trade. The good or service being traded is homogeneous. Each agent has perfect information about the trading price; they would know if someone else were trading at a better price than they were offered. Impediments to competition arising from collusion or government regulation are absent. Lastly, there is freedom to enter or exit the market. For further discussion of the concept, see Baumol et al. (1992, pp. 579–582) and Krebs (1990, p. 263).

Present discounted value The value of a future sum of money discounted to the present; the rate of discount is compounded for each period into the future. For example, at a 10 per cent annual rate of discount, \$121 received two years from now has a present discounted value of \$100 (= $121/(1.1)^2$).

Producer surplus A money measure that equals a defined area above a supply curve. The area is bounded by the vertical axis (which measures price) and, from above, by the purchase price. See also consumer surplus.

Real exchange rates adjust movements in a country's nominal exchange rate for changes in product prices. Approximately,

% real exchange rate =

% nominal exchange rate + % domestic price index – % foreign price index

where % denotes the percentage change in each variable. To illustrate, suppose that in some year the Australian dollar depreciates



by 3 per cent relative to foreign currencies, while prices increase by 9 per cent for Australian products and by 2 per cent for foreign products. Australia's real exchange rate has then appreciated by about 4 per cent (-3 + 9 - 2). In other words, Australian products have become 4 per cent more expensive relative to foreign products. Strictly speaking, Australia has many real exchange rates, one for each of the other world currencies. However, an overall real exchange rate is derivable using trade-weighted indices.

Shadow pricing In economic analysis, the substitution of a notional price for an actual market price. The aim is to measure the value or cost to society of engaging in some activity. A classic case is the employment of additional labour by a business. The market price of the additional labour comprises the wage or salary plus other compensation. But some BCAs replace the market price with a much lower shadow price, to measure the cost of additional labour to society (chapter 5).

Social cost The cost of something to society. No distinction is implied between 'social' and 'economic' costs, although non-economists often draw one. For example, some people might call the crop damage from a storm an 'economic cost', and the deaths from the storm a 'social cost'. Economists would call both of them 'social costs'.

Social time preference rate For society, the rate at which consumption in one period can be substituted for consumption in the previous period, without any change in overall well being.

Supply curve For a good on service, the quantity supplied depends on the price that can be obtained by the supplier. Factors other than price which influence supply are held constant for a given supply curve.

Transfer payment A payment other than for a good or service, such as government pensions.

Unemployed The unemployed consist of three groups of persons aged 15–69 and who are not employed. By far the largest group consists of persons who are looking for work and who would be available to start within a week. Persons who are waiting to start a new job form another group, but they accounted for only about 3 per cent of unemployed Australians in September 1997 (ABS 1997a). The third group is even smaller, according to ABS advice. Persons in this group are waiting to be called back to a job from which they were recently stood down.

Unemployment rate The percentage of the labour force that is unemployed.



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ABBREVIATIONS

Australian Automobile Association
American Association of State Highway and Transportation Officials
Australian Bureau of Statistics
Australian Council of Trade Unions
Australian Government Publishing Service
(former) Bureau of Industry Economics
(former) Bureau of Labour Market Research
(former) Bureau of Transport and Communications Economics
Bureau of Transport Economics
US Congressional Budget Office
(former) Commonwealth Bureau of Roads
Centre for Economics and Business Research
Centre for International Economics
Centre for Regional Economic Analysis (University of Tasmania)
Department of Finance
Department of Transport and Regional Services
European Centre for Infrastructure Studies
Economic Modelling Bureau of Australia
Economic Planning Advisory Commission
Federal Highway Administration



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FTA	Federal Transport Authority (Aust.)
FTA	Federal Transit Administration (UK)
GAO	US General Accounting Office
IAC	(former) Industry Assistance Commission
IC	(former) Industry Commission
IRU	International Road Transport Union
JFA	Jack Faucettt Associates
MTRU	Metropolitan Transport Research Unit
NAASRA	(former) National Association of Australian State Road Authorities
NCHRP	National Cooperative Highway Research Program (US)
NIEIR	National Institute of Economic and Industry Research
NTPT	National Transport Planning Taskforce
OECD	Organisation for Economic Co-operation and Development
OMB	US Office of Management and Budget
PEC	Planning and Environment Commission
PIARC	Permanent International Association of Road Congress
RAC	(former) Resource Assessment Commission
RCA	Road Construction Authority (Victoria)
RTA	Roads and Traffic Authority (New South Wales)
RTF	Road Transport Forum
SACTRA	UK Standing Advisory Committee on Trunk Road Assessment
TNZ	Transit New Zealand

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